# CIVIL ENGINEERING

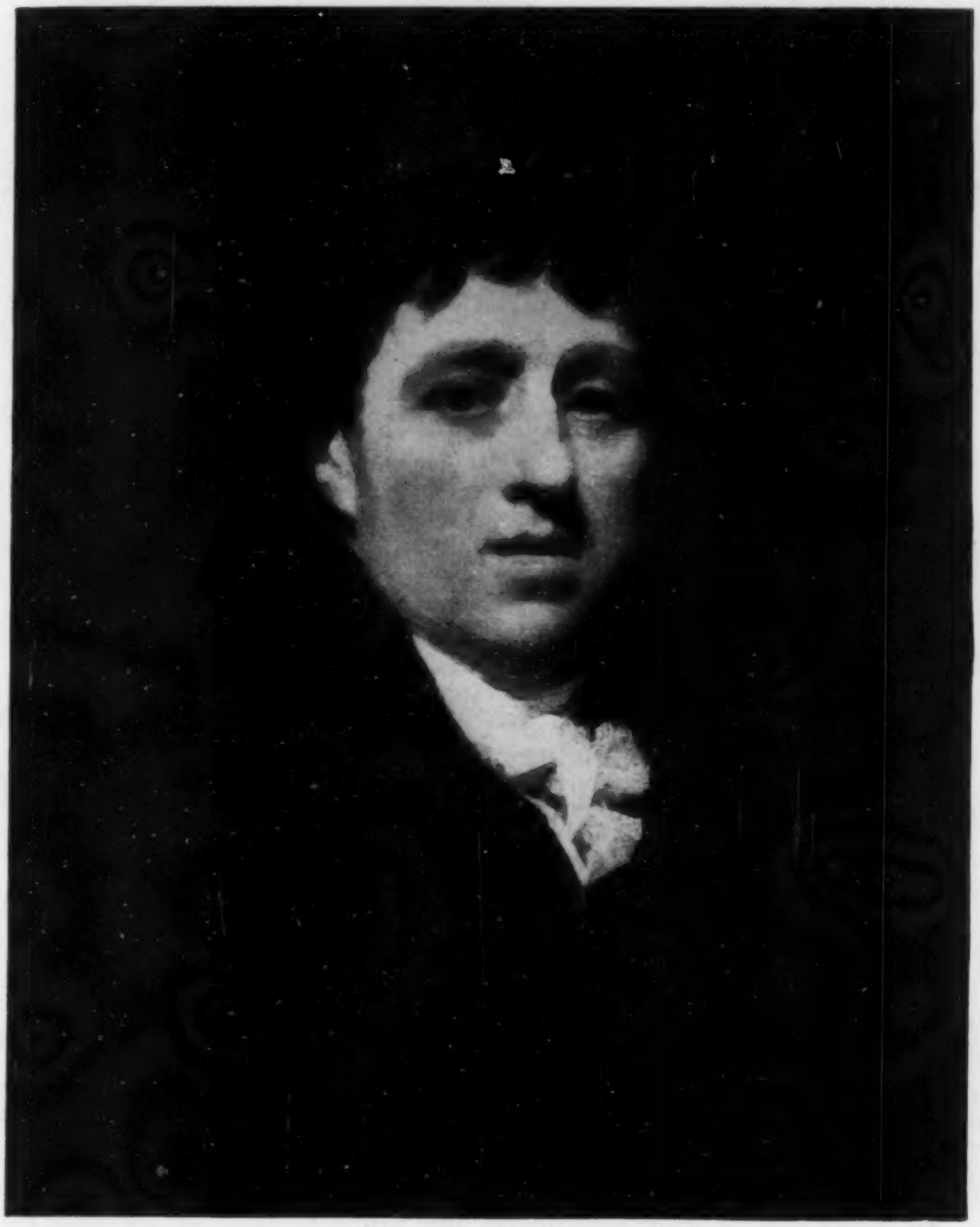


*Published by the American Society of Civil Engineers*

Four-Inch Sheathing in Boston Harbor Completely Destroyed by Marine Borers
A Description of Marine Borer Activity Appears on Page 105

*Volume 7 — Number 2*

FEBRUARY 1937



THOMAS TELFORD, 1757-1834

*From an Oil Painting by Sir Henry Raeburn, Royal Academician. Reproduced by Courtesy of the Trustees of the Lady Lever Collection, Port Sunlight, Cheshire, England*

## Among Our Writers

WILLIAM F. CLAPP was in charge of the departments of *Mollusca*, *Bryozoa*, and *Tunicates* at Harvard for 15 years. For the past 10 years he has been connected with the Massachusetts Institute of Technology in the department of biology, but since 1930 has devoted practically all of his time to his private laboratory. The address abstracted herein was delivered in New York on April 15, 1936.

ROBERT B. BROOKS served for 8 years as director of streets and sewers in St. Louis. He represented the International Association of Public Works Officials at conferences in Europe in 1931 and 1935; also the American Road Builders' Association in the dedication of the Inter-American Highway at Mexico City in July 1936. The address abstracted herein was delivered in St. Louis on May 25, 1936.

R. A. MOYER holds bachelor's and master's degrees in civil engineering. In 1921, after practical experience in highway location work, he became a faculty member of Iowa State College, where he has served successively as instructor, assistant professor, and associate professor. He is the author of numerous articles in the highway research field.

JOHN F. BAKER was engaged first on studies of the strength of rigid airships and later as an engineer in the British Government's Department of Scientific and Industrial Research. Since 1933 he has been professor of civil engineering at the University of Bristol.

JOHN ARMITAGE was captain of Rugby fives at Cambridge University, 1931–1932. For the last five years he has served as editor of the London journal, *Squash Rackets and Fives*.

E. W. LANE has been connected with a number of flood-control projects, including those for the Miami River, Ohio; for the Arkansas River at Pueblo, Colo.; for the Mississippi River, south of Cairo; and in China for the Huai and Yangtze rivers. He has also been engaged on studies for numerous American waterways.

JAMES B. HAYS, after 15 years in irrigation and drainage work, entered the employ of the Aluminum Company of America in 1926, serving chiefly as resident engineer on important parts of that company's Little Tennessee power project. He went with the U. S. Bureau of Reclamation in 1934, specializing on grouting, particularly of contraction joints. Mr. Hays is now a construction engineer for TVA.

VOLUME 7 NUMBER 2

AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852

February 1937

Entered as second class matter September 23, 1930, at the Post Office at Easton, Pa., under the Act of August 24, 1912, and accepted for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on July 5, 1918.



# CIVIL ENGINEERING

*Published Monthly by the*

AMERICAN SOCIETY OF CIVIL ENGINEERS
*(Founded November 5, 1852)*

PUBLICATION OFFICE: 20TH AND NORTHAMPTON STREETS, EASTON, PA.
EDITORIAL AND ADVERTISING DEPARTMENTS:
33 WEST 39TH STREET, NEW YORK

## *This Issue Contains*





SUBSCRIPTION RATES

Price, 50 cents a copy: $5.00 a year in advance; $4.00 a year to members and to libraries; and $2.50 a year to members of Student Chapters. Canadian postage 75 cents and foreign postage $1.50 additional.

*Member of Audit Bureau of Circulations*

# Something to Think About

*A Series of Reflective Comments Sponsored by the Committee on Publications*

## The Engineer and the Modern World

THERE seems to be a growing consciousness on the part of the public and of leaders in public affairs, that engineering is playing, and will continue to play, an increasingly important part in the activities of the modern world. In the field of consumers' goods, for example, it has been made clear that, while some adjustments may be made in the division of earnings between capital and labor, a greatly increased standard of living for labor can come only through reduction in the basic costs of production, that is, through engineering advance and progress. Any attempt to achieve a higher standard of living through increases in wages alone must, in the majority of cases, be reflected in an increase in cost to the consumer. Recalling that it is the wage earner himself who is the principal consumer, it is obvious that juggling the payroll cannot, in the end, have a very marked effect in raising standards of living.

A brief review of the history of recent advances amply demonstrates the fact that two basic factors have made it possible for the American people to maintain a constantly increasing population on a constantly increasing standard of living—the unparalleled natural resources of the American continent and so-called technological progress. During the nineteenth century the American people swept westward across a continent in which Nature's gifts offered an opportunity to all for a fuller and more abundant life.

*A Changing Order.*~Today this age of largely uncontrolled, often destructive, and catch-as-catch-can exploitation has come to an end. We stand in the backwash of the often ill-advised, wasteful, and ineffective methods of a remarkable era of social progress and we seek ways and means of continuing a rate of growth in the development of standards of life that has no parallel in all human history. Like children not only are we fretful upon discovering that the stick of candy is nearing its end but we await impatiently the advent of a new and bigger stick. All sorts of wild notions are brought forward as revelations of the short and direct route to new and greater opportunity. But, as these have successively failed to produce the wished-for result, or as more sober and careful thought has demonstrated their fallacy, the idea has become more widespread that, after all, technological knowledge and methods have also played a major part in the stupendous advances of the last century, and, now that a more stable order prevails, they are the only promise of continued progress toward the ideal of ensuring to a constantly increasing population a constantly rising standard of living.

This feeling of unrest and impatience with the apparently reduced tempo of American progress, which has accompanied the depression, has undoubtedly been encouraged by the visionary and ridiculous promises of enthusiastic but misinformed prophets and dreamers. The methods of modern journalism also have too often encouraged false hopes in the public mind. In an attempt to secure support for much needed and very necessary research, science has supplied data for a propaganda which, even admitting a soundness and unselfishness of motive, has misled and misinformed the public. No one knows whether, on the one hand, science is about to give birth to another discovery which will continue the rapid advance of recent years, or whether we are in for a more or less static era of assimilation and coordination. The latest developments of the cosmic ray and the dissected atom, however, are still front page news and the average man has been led to expect great things of these developments—not ten or twenty years from now, but tomorrow at the latest.

***Application of Knowledge Is Important.***~Calmer minds, however, realize that, after all, it is not the scientist but the engineer who makes available to mankind the increasing technical as well as scientific knowledge which is such an important factor in modern life. Science, in short, is knowledge—knowledge of the world in which we live—but knowledge is, in itself, of secondary importance today. Rather, progress depends on our ability to apply and use knowledge as a tool with which man can increase his control over his environment and thus make the world a better, safer place in which to live.

The suspicion that it is even more difficult to apply knowledge than to discover it, is slowly gaining headway. Time was when the discovery of any useful truth was almost immediately reflected in improvements in life or living. Today this is no longer true—we know far more than we are able to apply. It is the man who has developed the technique of applying knowledge to the material needs of man who is in demand—the engineer.

The scope of engineering today is difficult to define simply because the viewpoint and methods of the engineer are being constantly applied to a wider and wider field. It has become almost impossible to write a defi-

nition of engineering that will be broad enough to include all engineering activities and yet be explicit enough to constitute a real definition.

***Business Sees a Light.***~One of the first groups to adopt the engineering viewpoint and engineering methods was business. It used to be said—and it is still true in many fields of business activity—that the best training for a business career was that offered by an engineering school. With the Mechanical Revolution, the engineer became an important figure in industry and, through industrial contacts, has exercised an important influence on business. The modern business college may, to a very considerable extent, be looked upon as an outgrowth of the earlier engineering school both in methods, viewpoint, and in inspiration.

While private enterprise has thus to a large extent adopted the common-sense viewpoint and methods of the engineer, public organizations—government—have been slow to do more than employ the engineer as an agent. The engineer has been called upon to design and construct great public engineering works but he has seldom been asked for advice on questions of administration or policy. In fact our federal, state, and municipal constitutions and charters were drawn up in an age when the functions of government were limited to the protection of life and property, and when, almost without exception, little or no provision was made for public works or the many similar engineering activities of the present day. Such tinkering as has been needed to permit public construction has been provided by legislative talent with little reference to engineering principles of efficient organization and administration. Policies have been determined by legal requirements and political expediency rather than by any sane and rational planning to meet modern engineering requirements of efficiency and effectiveness.

***Adopting an Engineer's Viewpoint.***~Apparently the tide is turning. The engineer is to be called upon to aid in designing public policies and programs as well as public works. He has no mysterious and magic formula to suggest, but he has a viewpoint which is fundamental to the sane solution of any problem and a technique that reduces, as far as is humanly possible, the risk of making costly errors or mistakes. These should be valuable assets to a nation, state, or community as well as to private enterprise, but they promise no simple and easy solution of our governmental problems. On the contrary, they require a careful, honest, unbiased attempt to see, appraise, and evaluate all angles of a problem and similarly honest and painstaking planning to meet these needs. The engineer realizes that public problems, unlike many private ones, involve not single but often many interests. That these interests are all entitled to consideration goes without saying, and the final answer must be framed to meet the sometimes conflicting demands of various social, political, and economic forces. The public interest requires, however, that the final answer to these problems shall be the best that modern standards and methods can devise. The viewpoint and the method must be those of the engineer.

*FROM time to time papers by members of our Society dealing with questions of the public relationships of our profession have appeared in* PROCEEDINGS *or in* CIVIL ENGINEERING. *Many other Society papers have, less directly, involved problems of this nature. The Committee on Publications takes this opportunity to call special attention to these papers. They deal with questions which should have the careful attention of all our members. We as professional men must endeavor to "think these problems through," to give due attention to all viewpoints, whether they do or do not conflict with our own, and to balance and appraise all possible solutions with the unbiased fairness and honesty of the true engineering mind. We are going to be called upon far more frequently than in the past for such advice and counsel.*

*Through the coming year the Committee plans that there shall appear regularly in this section, as a new feature, a series of commentaries on issues that should be thoughtfully appraised by engineers. Some of these articles will be initiated by the Committee and others doubtless will be submitted. All will be subject to its acceptance. The intent is to provoke thought on the part of members. Discussion of these topics will be published as letters to the editor.*

COMMITTEE ON PUBLICATIONS

VOLUME 7

CIVIL
ENGINEERING

FEBRUARY 1937


NUMBER 2

# The Activities of Marine Borers

## *Presenting Some Little-Known Facts About Ship-Worms and Other Destructive Organisms*

*By* WILLIAM F. CLAPP
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*DESTRUCTIVE bivalves, particularly teredo and limnoria, are responsible for enormous annual damage to piles, bulkheads, and other wooden marine structures, but until recently the available knowledge of their life histories was insufficient to serve as a basis for attempts at control. It has now been determined, chiefly by the use of test boards, that the period of attack is limited to little more than two months in northern waters, although once inside the surface, the borers continue to eat unless the water temperature drops to just above the freezing point, when they become dormant. Since a lack of dissolved oxygen and a concentration of hydrogen sulfide are detrimental to borers, pollution of coastal waters hinders their development, whereas a reduction of pollution, although otherwise beneficial, tends to increase the scope of their activities. The following article is abstracted from an address made by Professor Clapp during the past year before a large and enthusiastic audience at a meeting of the Metropolitan Section of the Society.*

PREVIOUS to 1890 very little was known about the distribution of the various kinds of marine borers. In a great many cases where piling was damaged, it was considered to have been caused through the action of scour in gradually wearing away the pile until it had been tapered to a pencil point. Many publications previous to 1890 and as late as 1898 were illustrated with diagrams of piling so damaged, labeled as being the effects of scour.

It was not until 1922 that any very extensive survey was made. At that time, under the direction of William G. Atwood, M. Am. Soc. C.E., a very thorough survey was made of the entire Atlantic coast and of some of the West Indies. It was discovered that except for a few isolated cases in Boston harbor, no teredo were to be found north of Cape Cod, although Provincetown, Mass., had quite a severe attack.

During the years that the 1922 investigation was being conducted—1922, 1923, and 1924—hundreds of test boards were installed in harbors along the Atlantic coast from New England to Florida and into the Gulf of Mexico. Every two weeks a block was removed from each of these test boards and forwarded to the laboratory for examination.

In this way it was possible to determine just where the borers were working and which species were active, also during what parts of the year the rate of activity was greatest. It developed that attacks by marine borers occur only during the breeding season, which lasts from 8 to 10 weeks, and on the Atlantic coast north of New York about two months—July and August—with an occasional early attack in the latter part of June. During the other months there is no danger of attack from molluscan borers (ship-worms). The investigation was discontinued in 1924, and only scattered observations of importance were made during the next ten years.

In 1934 evidence of greatly increased destruction by these organisms in New England waters led to the forming of a committee to undertake further studies of the conditions in harbors from Eastport, Me., to Stamford, Conn. The results of this investigation to date have demonstrated very clearly that there has been a marked increase in the losses due to marine borers in that area when compared with the findings of a decade ago. Considerable evidence indicates that this destruction is mounting in the vicinity of New York, and also in South Carolina. Examinations of marine properties in New Brunswick, Nova Scotia, and Newfoundland have proved that structures in harbors which previously were immune from borers are now being seriously damaged, if not destroyed. It therefore seems probable that the various species of destructive marine organisms are increasingly active, not only in New England but along the entire North Atlantic coast.

Since descriptions of this increased destruction have appeared in a number of recent publications it is not necessary to cite specific examples here. Admitting the increasing seriousness of the situation, let us consider briefly the various factors having more or less bearing on the problem as a whole.

### CORRECT CLASSIFICATION IMPORTANT

The more important organisms included in a broad classification of marine borers are the following: In the subfamily *Mollusca*, the genera *Teredo, Pholas, Martesia, Xylophaga, Lithodomus, Zirphae*, and *Petricola;* in the subfamily *Crustacea*, the genera *Limnoria, Chelura*, and *Sphaeroma*. Several hundred different species have been recognized and described in these ten genera. Since methods of protection which are of value for one species may be worthless for another, proper classification is evidently a fundamental factor in the problem. This is the task of the taxonomist.

Considering only one of the genera of marine borers—the teredo—some of the difficulties encountered by the taxonomist can be briefly outlined. More than 300

different kinds have been discovered and descriptions of their characteristics published. The more important factors to be considered in such studies of teredo are the external structure, subdivided into the shell (shape, size, and sculpture), the siphon tube (simple, divided, and concamerated), and the pallets (shape, blade, and stalk).

STANDARD MARINE PILING EXPOSURE TEST READY FOR SUBMERGENCE
View at Newport, R.I., Testing Station. The Log Will Be Suspended from an Iron Pipe by a Cable Through the Pre-Bored Hole

The shell is composed of a dozen or more areas, each of which is considered separately for consistent variations. Minute denticles are formed on certain restricted parts of the shell, by means of which the organism is capable of enlarging its burrow. High magnification and careful microscopic technique are necessary to study and understand the shape of these cutting teeth. Even the condition of the parts being studied is of major importance. If the specimens become dry, for example, distortion takes place, and correct identification is rendered very difficult. Some distorted specimens have been erroneously described as new species.

### THE ANATOMY OF THE TEREDO

The external characteristics of most organisms are not firmly fixed. Variation is more pronounced there than in the anatomy of the internal organs. In modern research, the taxonomist therefore stresses the study of the less variable internal structure. The important specific characteristics found in the internal structure of the teredo are in the reproductive organs, digestive tract, circulatory system, and muscular arrangement.

A vast amount of research has been devoted to these and other parts of the internal structure of the teredo. The reproductive organs appear to be of prime importance, since the sexes are separate and fertilization varies widely in the different groups. In one group, the eggs and sperm are expelled into the water, and fertilization depends upon chance. In this group the embryos are free-swimming for a considerable period of time. Currents, tides, and winds may produce a wide distribution. In another group, the sperm are taken into the body cavity of the female, and fertilization of the egg occurs there. The entire development of the embryo takes place within the female's protective gills, and when the young teredo finally leaves the parent, it is capable of immediately drilling its own home. It can, therefore, be easily understood that a knowledge of the reproductive organs is of value in attempting control.

The digestive tract is of equal importance in taxonomic problems, and a study of it not only aids in determining the species, but also yields information of value for use in combating, with toxic materials, the ravages of the organisms. Some materials considered as toxic have little actual effect on the digestion or health of the *Teredinidae.*

Even a study of the powerful muscles is of value in considering methods of protection, for it is by means of these muscles that some species are able to plug the entrances to their burrows so tightly with the pallets that poisoning of the surrounding water has little or no effect. The plugs may be effective for several weeks; hence the failure of many attempts to eliminate the teredo by poisoning the surrounding water. However, some of the molluscan borers are not so well equipped, and therefore can easily be exterminated in this manner.

This, and many other angles of purely scientific research, have a similar more or less direct application in economic problems. But since the scientific investigators of intricate problems in taxonomy and anatomy are rarely interested in the practical application of their researches, it remains for others to correlate their findings.

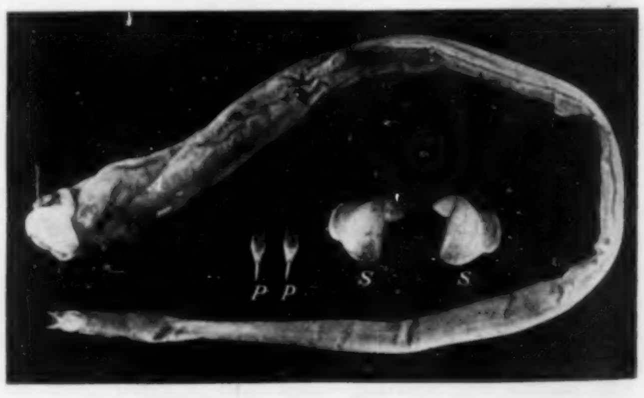
Another factor which has some bearing on the classification of the marine borers (and more particularly the teredo) is the range of distribution both in bathymetrical and in faunal areas. Too much dependence has been placed on distribution. Specimens of the same species have been described as distinct, although there may be little else to differentiate them other than the fact that they have been taken from widely removed localities. For this reason, the specialist cannot possibly identify many species without first knowing the locality from which the specimens came.

There are many records of timbers containing teredo being deposited on shores thousands of miles from the original habitat. It is known that these and other mollusks have flourished in foreign harbors where conditions similar to those of their original habitat exist. Depth and latitude are nevertheless factors of importance in classification, and as with all other angles of marine-borer research, have evident economic value.

### FACTORS CONTROLLING ACTIVITIES OF BORERS

A second major branch of marine-borer study has to do with the life history of the various organisms. Among the major factors which might be considered under this heading are habitat, breeding season, length of life, food, periods of activity, associated organisms, natural enemies, and cyclic variations.

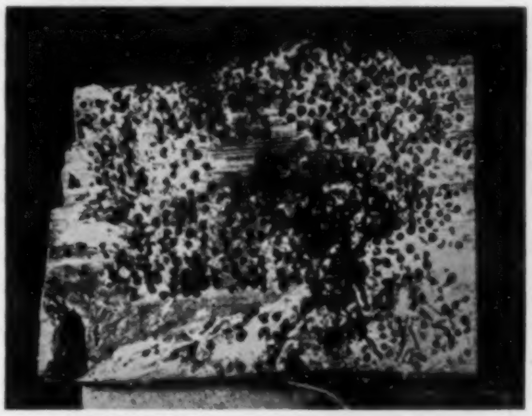
Next to the classification of the marine borers, probably more intensive study has been devoted to habitat factors




TEREDO NAVALIS, SHOWING ANIMAL *A*, PALLETS *P*, AND SHELL *S*
Minute Denticles on the Shell Are Used in Burrowing

than to any of the other phases of the research. The principal items to be considered are salinity, temperature, pollution, hydrogen-ion values, dissolved oxygen, and sulfureted hydrogen.

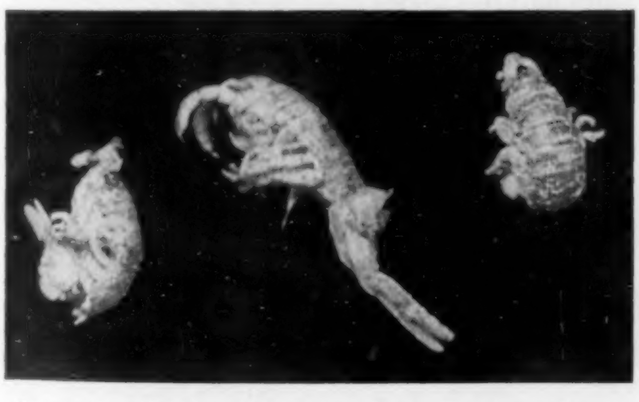
The favorable range of salinity is known for comparatively few species. It is certain that this range varies with each species, even to the extent that some of the *Teredinidae* require fresh or almost fresh water, while others such as *Teredo norvegica* and *Teredo thompsoni* can rarely exist in water which is even slightly brackish. The recently published work of Dr. Felix Roch opens up an entirely new field on account of his discovery that variations in one or another of the salts in salt water has a marked influence on the activity of the borers. That is, the total salt content is of less importance than the relative percentage of the seven or eight more important salts found in normal salt water. Future research in this virgin field may reconcile the contradictory results found in past studies where great variation in marine-borer activity has been recorded for practically identical salinities.



A Test Section After Six Months' Submergence at Marion, Mass., Showing Ravages of Teredo Navalis

The temperature of the water has considerable bearing on the activity of the borers. Certain temperatures are known to be most favorable—in fact necessary—for certain species of the *Teredinidae.* Likewise, each species ceases active work and becomes dormant when the temperature falls below a certain point. This low point varies greatly with different species, and occasionally with the same species, but in the latter case careful study will probably prove that there are geographical races of some teredo which have acquired the ability to breed and remain active at lower temperatures than closely related forms in warmer climates.

Temperature studies have proved of great practical value in marine construction. For example, exact knowledge of the temperature-governed breeding seasons, and consequently the seasons of teredo attack, has made it possible to eliminate protective measures against the teredo in temporary construction in many of the harbors along the Atlantic coast. As a result of this research, it is now known that in any harbor north of Cape Cod, there is a period of ten months in every year during which there is absolutely no possibility of teredo attack.



Specimens of Chelura, Magnified About Fourteen Times
This Species Has Caused Severe Damage in New London, Conn.

Pollution is probably of equal or even greater importance than temperature when considering conditions favorable for the development of marine borers. The effects of temperature are most noticeable in the case of the molluscan borers and are not as evident in the life history of the crustacean. Excessive pollution, on the other hand, forms a decided barrier to all the borers. Comparatively clean water is the medium necessary to support a prolific marine fauna and flora, although the requirements vary with the different species. A number of locations can be cited where foul harbor conditions have prevented destructive attack for many years, and where reduction of pollution has resulted in an almost immediate invasion by marine organisms, and later by teredo and limnoria in excessively destructive numbers. The condition of the harbor at Lynn, Mass., is an excellent example of what may be expected to follow reduction of sewer and mill waste. In the harbors of Boston, Providence, and New York, changes are contemplated which will result in measurable purification of the harbor waters. There is not the slightest question but that this will result in conditions favorable for the borers, and, unless precautions are taken, heavy losses in marine structures will surely follow.

Despite the consequences of reduced pollution, extensive and costly marine reconstruction work is being undertaken in areas adjacent to New York where even now the marine borers are active, and where this activity is certain to increase. The broadest definition of the term pollution is intended to include not only sewage, with its resulting low free oxygen and pH values, but also the even more important mill wastes, oils, and catch-basin overflows.

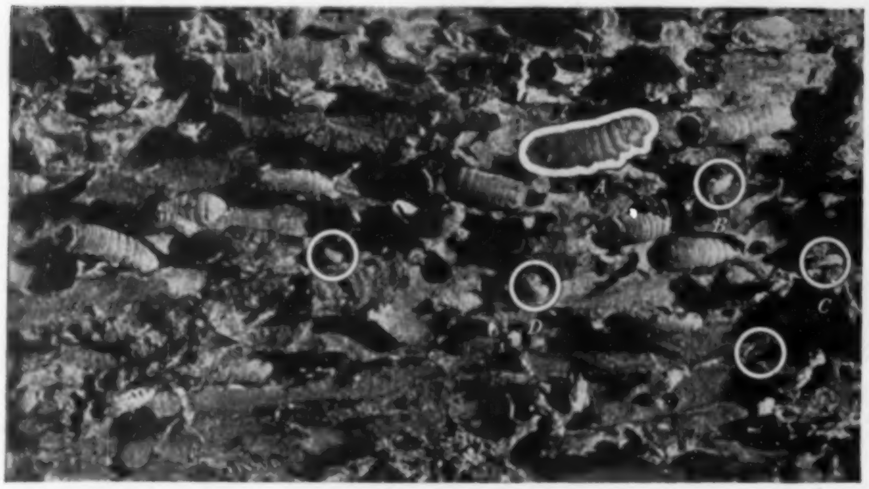
The food requirements of many of the borers have been carefully studied by many investigators. At the present time the consensus of opinion is that all the marine borers, including the teredo, burrow primarily for food, not for protection, and that cellulose is a necessity. Dr. Roch, as a result of his recent studies of teredo, is in complete agreement with previous investigators in this matter. It can be readily understood that this is a factor of prime importance in any selection of toxics to control the borers, and definite proof should be sought. In spite of the marvelous technique employed by Dr. Roch and the startling results obtained, there are still several factors which indicate that the teredo burrow for protection and can live entirely on micro-organisms in the water, without cellulose. This research should be continued until all doubts are eliminated.

The presence in a given locality of organisms ordinarily associated with the teredo is an excellent indication of conditions favorable to one or another of the marine borers. The occurrence of species requiring identical conditions indicates that marine borers either are present or would survive if introduced. Although the study of associated organisms has only been undertaken in comparatively recent years, the severity of attack by borers can be estimated even now by observing the relative abundance of the associated fauna and flora. Additional research in this field will provide information of great value. European investigators are now stressing the importance of this angle of marine-borer research.

Natural enemies have been considered as providing

possible controls. Carnivorous worms are frequently found in teredo burrows and certain species of protozoa and bacteria have been suggested as natural enemies. There is evidence, on the other hand, that all three of these organisms are merely scavengers and not killers, and that if a true natural enemy exists, it is yet to be discovered.

Cycles of abundance and scarcity have been suggested as important factors in marine-borer activity. Evidence of years of abundance of *Teredo navalis* at 70-, 30-, and 10-year intervals exists, the 70-year cycle being the one of greatest intensity, and the 10-year showing the least. The spasmodic investigations of the past have not provided sufficient data on which to base any definite conclusions in regard to the existence of regular cycles. Only intensive studies covering a period of many consecutive years can satisfactorily determine whether or not the numbers of marine borers follow regular cycles of abundance and of scarcity.



LIMNORIA LIGNORUM ACTIVELY BREEDING IN AN OAK PILE, EAST BOSTON

Organisms in All Stages of Development, Enlarged About $4^1/_2$ Times. Specimen *A* Is a Full-Grown Female; *B* Is Very Young (Note the Pigmented Eye); *C* Is Young; *D* Is Immature. The Unlettered Circles Enclose Very Young (Left) and Immature (Right)

ADDITIONAL STUDY NECESSARY

Some of the more important factors in marine-borer research have now been very briefly considered. This outline has been intended to indicate that none of the chapters can be considered closed, but can and should be added to. This thought leads naturally to a consideration of what may be expected from future research. The data necessary to solve some of the doubtful problems will be obtained by the study of existing structures, more extensive use of test boards, the establishment of permanent testing grounds to handle exposure tests, and laboratory research.

The examination of existing structures at intervals has resulted in the past in the accumulation of data of great value in determining the relative efficiency of various methods and materials in resisting borer attack. Unfortunately, original specifications are generally difficult to obtain, and the results of these examinations are therefore not conclusive. Standard specifications (covering the various items which should be considered in a thorough inspection of marine structures) should be followed in order that full value may be obtained for construction expenditures, and also for the purpose of comparing conditions in various localities.

Test boards have proved of the greatest value in recent marine-borer investigations. It seems certain that in the future they will be widely used, not only by investigators but by owners of marine properties who desire definite information in regard to the condition of their structures below low water. The test boards record not only the marine fauna and flora of a given locality, but also any invasion by marine borers and the intensity and duration of such attack, thus providing a form of insurance against unsuspected destruction. The specifications for the construction and handling of the various types of test boards have been modified and improved. Where standard types are installed, comparable results can be obtained from boards in widely removed localities.

The value of firmly established testing grounds where exposure tests can be conducted cannot be overestimated. Many of the testing grounds used in the past have failed. The principal factor to be considered is permanence. Protection from severe storms and theft is also necessary, as well as frequent supervision and inspection by those in direct charge.

With the assistance of the United Fruit Company, the Standard Fruit Company, the Standard Oil Company of New Jersey, the Aluminum Company of America, and various state and federal departments, a number of excellent testing grounds have been firmly established in the United States and also in several countries in Central and South America. Several hundred test samples of various materials have been submerged at these stations with every assurance that long-time exposures can be safely conducted, without fear of loss before complete results can be obtained. As in the case of the test boards, standard specifications have been adopted for these exposure tests in order that comparable results may be obtained.

Admitting the great value to be derived from these tests, it seems certain nevertheless that in the future the most important work will be conducted in the marine biological laboratory. Investigators have been handicapped in the past because few marine research laboratories have the proper equipment, and even fewer are operated for more than a few months during the summer. For a satisfactory solution of the problems involved, continuous study throughout the entire year is essential.

The laboratory investigations conducted by Dr. C. P. Sigerfoos, Dr. Jean T. Henderson, Dr. Felix Roch, and many others, even though generally confined to the summer months, have so clearly demonstrated the value of this type of research that it certainly will be stressed in all future investigations.

The fact that in properly installed laboratory aquaria all experiments can be constantly and carefully controlled, is sufficient to indicate the value of the results to be obtained. With a constant supply of salt water available throughout the year and with well-designed aquaria, experimental work can be conducted upon practically all the various factors associated with the life history of the marine borers, and on all methods and materials designed to control their activities.

It is to be hoped that in the near future a laboratory of this type will be established which will be devoted to continuous research on the various problems connected with marine borers.

# International Highway Across Europe

*Observations and Data on Continuous Traffic Artery from England to the Bosphorus*


*By* Robert B. Brooks

Member American Society of Civil Engineers

Consulting Engineer, St. Louis, Mo.


*In traveling from London to Istanbul, the motorist covers a distance of almost 2,000 miles, corresponding approximately to the mileage between San Francisco and New Orleans. In the latter trip the motorist would drive through parts of six states, but in the former he would pass through no less than nine different European countries, each with an individual language and customs regulations. He would drive, furthermore, over roads varying all the way from modern hard-surfaced highways to primitive cart-tracks. As a partial remedy for these difficulties, European Highway No. 1 has already been modernized or constructed new from London to the southern boundary of Hungary, while the remaining 40 per cent to Istanbul is scheduled for completion in the near future. After discussing the international highway, Mr. Brooks passes to a description of the status and development of road systems in the participating countries. The article is abstracted from an address delivered during the past year before the St. Louis Section.*

A TWO-THOUSAND-MILE European motor road, extending from London, England, to Istanbul (Constantinople), Turkey, is now nearing completion. A tour over important parts of this highway, such as it was my privilege to enjoy in 1935, yielded some enlightening information on this ambitious undertaking, which may prove interesting to other American engineers.

The nine governments participating in the international highway, which is scheduled for completion within two years, are England, France, Belgium, Germany, Austria, Hungary, Yugoslavia, Bulgaria, and Turkey. The route is shown in Fig. 1. The completed section extends from London to Dover, thence across the English channel by ferry to Calais in France; to Ostend and Brussels in Belgium; thence to Cologne, Frankfort-on-Main, Nuremberg and Passau in Germany; Vienna and Kittsee in Austria; thence to Budapest in Hungary, terminating at Szeged. The part under construction extends from Szeged through Belgrade in Jugoslavia to Sofia, capital of Bulgaria; thence to Chorlu and Istanbul, Turkey.

The scheme for an international highway was first proposed by the Automobile Association of London to the International Touring Alliance (Alliance Internationale de Tourisme) in 1930. The International Touring Alliance, which is comparable to the American Automobile Association in the United States, represents five million members resident all over the world. Its proposal met with approval, and in September 1935 even the League of Nations took a hand, detailing an observer to attend the meeting in Budapest of delegates from each of the nations concerned.

In 1930 it was only proposed to create a motor road proper. Its exact length was to be 3,120 km, or 1,940 miles. Construction work was to be limited to providing satisfactory uniform width, eliminating dangerous corners, and making a dust-free surface upon a permanent foundation. But at the Budapest conference, certain standards were adopted by each of the nine nations. The more important of these standards, as reported by the Department of Scientific and Industrial Research and the Ministry of Transport of England, follow.

The road is to contain little new construction, but to consist mainly of a number of already existing sections. These are to be widened or reconstructed where necessary in order to conform with the following minimum requirements:

1. The road shall connect towns and cities of major importance by the shortest convenient route.

2. The minimum radius of curvature, except in built-up areas or in hilly or mountainous country, shall be 960 ft, and adequate transition sections shall be provided.

3. The maximum gradient shall normally be 1 in 20. In mountainous districts the gradient may be as high as 1 in 10 on short sections.

4. The crown shall be the minimum necessary to secure adequate surface drainage; on straight sections or on curves having a radius of over 1,600 ft the rise of the crown may vary from 2 to 3 per cent, according to the type of surfacing, while on curves of smaller radius a uniform crown shall be provided, the degree of superelevation depending on local conditions. Additional widening is recommended on curves where the radius is less than 960 ft.

5. The roadway surface shall have a minimum width of 19 ft 6 in., which shall be increased to from 26 ft 6 in. to 29 ft 6 in. on sections on which the volume of traffic is considerable; a divided roadway may be provided where there is heavy traffic in both directions.

6. Sufficient land to permit of future widening should be acquired as soon as possible.

7. The shoulders, which shall be at least 6 ft 6 in. wide, shall be sufficiently consolidated to accommodate traffic in case of emergency.

8. Footways and cycle tracks shall be provided, especially in the neighborhood of large towns.

9. On bridges and other structures the roadway surface shall have the same width as the approach sections.

10. In the design of new structures, allowance shall be made for the possible necessity for future widening and for a probable increase in the weight of vehicles.


Fig. 1. Route of International European Highway

Recommendations were made regarding the granting of increased customs facilities at the various frontiers. The traffic recommendations include the adoption of the system of traffic signs recommended by the Geneva Convention of 1931, and the suppression of all signs which do not conform with this system; the unification of registration formalities for motor vehicles; the erection in urban sections of direction signs bearing, where necessary, inscriptions in Roman lettering in addition to those in the lettering of the country; the protection of level crossings and the provision in their neighborhood of sound signals or luminous signs of a type likely to be easily perceptible in all weathers.

VIEW ON EXPRESS ROAD BETWEEN MUNICH AND SALZBURG, GERMANY, SHOWING CENTER AREA WITH BICYCLE PATHS
One of the Sidewalks Appears at the Extreme Left

Outlining briefly the condition of various sections of the international highway, it may be said that the road from London to Dover is in excellent condition, while the route from Calais, France, through Belgium to Cologne, Germany, has been a modern highway for the last ten years. A section of the new German Reichsautobahn goes from Cologne, through Frankfort-on-Main and Nuremberg to the Austrian frontier at Passau. Austria has a splendid road all the way from Germany to Hungary, and has even built a traffic-relief road on the outskirts of Vienna.

When the International Committee met in Budapest in September 1935, the splendid Hungarian section of the road was officially opened. The section from Budapest to the Jugoslavia border on the south is built of concrete with few curves and with plenty of sight distance. A German racing driver named Carraciola traveled at a speed of better than 200 miles an hour on it in his racing car. The existing roads in Jugoslavia and Bulgaria are being modernized. Balkan roads as a rule are merely ox-cart tracks and trails, not always safe, and varying from 12 in. of mud to 18 in. of dust, depending on the weather. The Turkish government has made a modern road of the final 20 miles into Istanbul.

With filling stations and garages strategically placed, and hotels inspected, the traveler knows he can anticipate some comfort and attention even in the most out-of-the-way places. Furthermore, he will need to carry only one set of customs papers. It will thus soon be possible to make the trip from London to Istanbul, 1,940 miles, within five days if one is in a hurry. If a reasonable length of time is allowed for sight-seeing, the tourist will be able to make a round-trip tour within one month.

The total length of all public roads in the United Kingdom, as of January 1, 1936, was 177,822 miles, of which 86 per cent are in England and Wales, and 14 per cent in Scotland. Ninety per cent of the roads are of some form of macadam, generally combined with either tar or asphalt. Portland-cement concrete is being used more extensively each year in the construction of main highways. Of the total of 150,000 miles of roads in England and Wales, only 20,000 are main traffic arteries. Of these 20,000 miles of Class I roads in England, only 273 miles are of concrete. Wood block accounts for 332 miles. Even small sections of rubber surfacing have been tried, as well as an iron-block surface.

### ENGLAND'S FIVE-YEAR CONSTRUCTION PROGRAM

A five-year program of highway construction, involving an estimated expenditure of £130,000,000, or approximately $650,000,000, has been approved by the government. As is usual with our British cousins, this work is designed for steady and progressive development. On March 4, 1936, the Minister of Transport gave the House of Commons certain information on this program.

Each lane of traffic will have a minimum width of 10 ft. On Class I routes, the number of traffic lanes required is to be determined by the flow of traffic. Where this amounts to 400 vehicles at the peak hour (an average of 6 or 7 a minute), more than two traffic lanes will be required and dual roadways are to be provided. Separate accommodations will be provided where required for pedestrians, bicyclists, and horse-riders, together with marginal spaces outside the standard widths of the main route for trees and shrubs and for communications with service roads.

The use of motor vehicles has been developing rapidly within the past few years. With this increase have come heavier traffic, a need for construction and extension of highways, and problems in traffic control. Automobiles in England are being driven at progressively higher speeds over winding, narrow roads designed for horse-

HAND LABOR IS USED AS MUCH AS POSSIBLE ON GERMAN EXPRESS ROADS

TYPICAL CONNECTION FOR GRADE SEPARATION, GERMAN EXPRESS HIGHWAY

drawn vehicles, and constructed only in short stretches. As a matter of fact, use of these reconditioned roads, together with the growing carelessness of pedestrians, has produced an increase in traffic accidents. A year ago a speed limit of 30 miles per hr was imposed in all built-up areas, and driving tests were made compulsory.

Bridge Over the Danube, Connecting the Cities of Buda and Pest in Hungary

The original traffic lights which were set up in London, I believe in 1930 or 1931, were installed after a visit of the then Minister of Transport to St. Louis, where we described to him the existing progressive signal on Olive Street and Lindell Boulevard. Regulations against loud motor noises have been studied and an attempt at enforcement has been made.

The United Kingdom, with its 177,822 miles of roads, has 1,843,845 automobiles, or 10.4 automobiles to each mile of road.

That part of European Highway No. 1, as the international highway is known, lying within the borders of France and Belgium, respectively, is a modern highway which needs no special improvement.

### German Superhighways Built by Federal Company

Germany is constructing in a minimum amount of time a system of double roadways totaling over 4,000 miles in length, which will connect every important industrial city in the country and every strategic point on its borders.

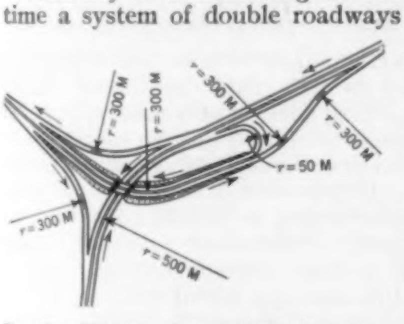
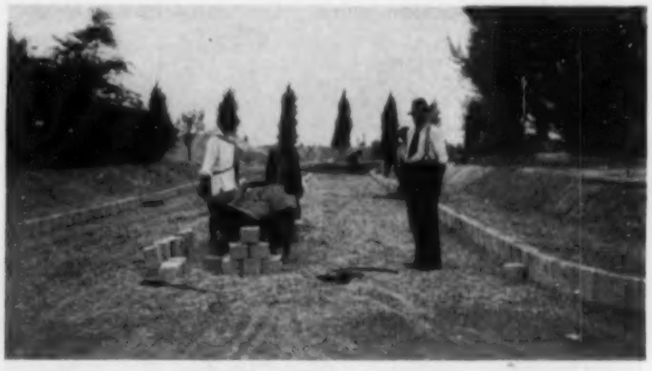



Fig. 2. Typical Three-Way Connection Used on German Express Roads

In the spring of 1933 the Deutsche Autobahn-Gesellschaft, a highway construction company, was organized. This company was entirely owned and controlled by the federal railroad, the Deutsche Reichsbahn Gesellschaft. The highway construction company's capital when purchased by the federal railroad on March 25, 1933, was 15,000,000 Reichmarks ($6,000,000). The railroad added 50,000,000 Reichmarks, or $20,000,000, and it has been further financed by rediscounting of notes and by state aid. The formation of the company was favored by Chancellor Hitler because of its value in (1) welding of Germany together politically and economically, and (2) putting great numbers of men to work quickly.

The project called for constructing within 5 years 7,000 km (4,350 miles) of main highways, at a cost of 3,500,000,000 Reichmarks ($1,400,000,000). The total amount spent during the fiscal year 1934–1935 was approximately 500,000,000 Reichmarks ($200,000,000). This program was launched to combat unemployment, aid industrial output, encourage greater use of automobiles, and eliminate competition between highways and railroads. Of course, these modern highways will facilitate troop movements in time of war. On the main arteries cities are by-passed with few exceptions; there are no railroad grade crossings; and all intersecting highways are separated. There is no speed limit.



Construction of a Stone-Block Feeder Road Coming Into Main Highway near Budapest

There are four classes of roads in Germany: Autobahn-Gesellschaft main arteries; federal roads; highways, first class; and highways, second class. The Autobahn roads belong to a government-owned corporation. Federal roads are the other main highways, usually built at the cost of the German government. First-class highways are those for limited traffic; their cost is usually borne by the provinces. Highways, second class, are connecting links of a local nature whose cost is usually borne by cities or districts.

There are virtually no dirt roads in Germany; practically all have some form of hard surface. In general, the federal and first-class roads are either of granite blocks, concrete, or macadam, with a tar surface. Second-class roads are also hard-surfaced, although a number are gravel or have a gravel base.

The writer inspected the stretch of road from Frankfort-on-Main to Darmstadt both by automobile and by airplane. Here it is estimated that a sum was spent equivalent to 3,500,000 Reichmarks or $1,400,000 per km (five-eighths of a mile). It has been further estimated that the cost of similar construction elsewhere is only about 250,000 Reichmarks per km. This is about 10 times the cost of similar railroad construction. We engineers can readily appreciate that officials could justify such enormous expenditures as an unemployment relief measure, and few labor-saving devices have been used. The German government feels that the expense is justified, just as many Americans feel that high costs are justified on projects under the Works Progress Administration.

The standard widths of the Reichsautobahn from outside to outside of shoulders is 24 m (78.7 ft). There are two reinforced concrete slabs $7^1/_2$ m (24.6 ft) wide. These slabs are separated by a width of 5 m or 16.4 ft, with a 1-m bicycle path and 3 m of parkway area on which grass and shrubs are planted which kill the glare of headlights of automobiles coming from the opposite direction. Outside each slab is another meter for sidewalks (usually made of small 4-in. or 5-in. stone cubes with tar joints and surface), and outside the sidewalks

still another meter for shoulders. Welded reinforcing for the paving is spaced 25 cm apart. The slab is 20 cm (about 7⁷/₈ in.) thick. It did not appear to have a thickened edge. Average cross-road connections were designed to be about 10,000 km (between 6 and 7 miles) apart. A typical three-way connection appears in Fig. 2.

On January 1, 1936, there were 11,300 men employed in actual construction work. Germany has a forced-conscription work plan. There is a uniformed division known as the Arbeitsdienst, performing an enforced service. At present when a man leaves school he must serve one year in the Arbeitsdienst, then he must serve one year in the army, and then three or four years as apprentice before he gets a job at a salary such as is paid to adults. Middle and lower classes already employed must leave their work and spend one year in the Arbeitsdienst and one year in the army before returning to employment. The workers corps is used to a large extent in highway construction. Every man must have a worker's passport. In it are stamped the dates and lengths of his services, together with the work he is best fitted for. It is easy to see that these men can be sorted out at a moment's notice for any needed service in time of war.

EXPRESS HIGHWAY IN ROLLING COUNTRY BETWEEN SALZBURG AND MUNICH

As an evidence of the speed with which work has thus far progressed on these 7,000 km of superhighway, within a little over two years 3,460 km have been approved and designed, 1,808 put under construction, and 112 completed (as of January 1, 1936). On June 1, 1936, 308 km was open to traffic. One thousand kilometers will be completed by January 1, 1937.

Germany has an area of 180,989 sq miles and a total length of 216,674 miles of roads. This gives an area of 0.8 sq mile to each mile of road, and with 968,000 automobiles as of January 1, 1936, means 4.4 automobiles to each mile of road.

### PROGRESS IN AUSTRIA, HUNGARY, AND THE BALKANS

Of all the countries in Central Europe, Austria has been in the worst economic condition during the last four years. For example, Vienna with 2,000,000 population is now serving a trade area of 6,000,000 whereas it used to serve ten times that number before Hungary became a separate country. Its section of European Highway No. 1 is completed, at a cost in 1934 of 59,000,000 schillings ($11,121,500).

The work which I actually saw was the traffic-relief roads in the vicinity of Vienna. The principal road being constructed was the Glockner Alpine Highway, which links southern Germany with northeastern Italy. Its highest point is 8,000 ft above sea level.

Austria now has an area of 32,372 sq miles, with 23,370 miles of roads, or an area of 1.4 sq miles to each mile of road. It has 34,956 automobiles, or 1.5 automobiles to each mile of road.

Hungary has recently completed its section of European Highway No. 1. This country has a road system approximately 18,000 miles in length, of which 11,500 miles have a waterbound-macadam surface, and 600 miles are treated with penetration asphalt. There are more than 100 miles of cement concrete and 1,200 miles of block, stone, wood, asphalt, and brick. It is planned to spend $40,000,000 on new construction. The budget in 1935 was 2,209,000 pengoes ($656,073) for maintenance. Most of the main arteries will be of cement and asphalt.

Hungary has an area of 39,911 sq miles, with 18,068 miles of roads, or an area of 2 sq miles to each mile of road. It has 14,349 automobiles, or 0.8 automobile to each mile of road.

While I have not inspected the roads in the Balkan countries of Jugoslavia, Bulgaria, and Turkey, it is my understanding from European engineers that they are rather primitive, at least along the proposed European highway.

Jugoslavia has an area of 96,737 sq miles, with a road mileage of 25,170, or an area of 3.8 sq miles to each mile of road; 6,176 miles are federal highways. It has 10,278 automobiles, or 0.4 automobile to each mile of road.

Bulgaria has 39,825 sq miles, with 15,317 miles of roads, or an area of 2.6 sq miles to each mile of road. Of the total mileage, 11,000 miles are of waterbound macadam. Bulgaria has 3,621 automobiles, or 0.2 automobile to each mile of road.

Turkey has an area of 294,492 sq miles, and a road mileage of 23,242 or an area of 12.7 sq miles to each mile of road. The Turkish government has recently completed the 20-mile stretch of concrete road from Istanbul towards Bulgaria. It has 7,350 automobiles, or 0.2 automobile to each mile of road.

### INTERNATIONAL HIGHWAY WILL PROMOTE PEACE

In order to make a comparison of areas and road mileages, it is interesting to note that the United States has an area of 3,026,789 sq miles and a road mileage of 3,068,919 miles, or an area of 1 sq mile to each mile of road. We have 25,163,789 automobiles, or 8.2 automobiles to each mile of road. If the reader has any illusions as to the character of our highways, he should consider that we have 1,413,800 miles of primitive roads, of which 1,000,000 miles are entirely unimproved or "paper" roads, and only 373,079 miles are improved.

The building of European Highway No. 1 will do more to promote friendly relations between the nine countries participating in its construction than all the diplomatic conferences that can be held. It is evident that in the United States within the last twenty years differences of opinion and lack of sympathy between East, West, North, and South have been diminishing because on the streets of any large city can be seen automobiles of almost any state in the Union. The resulting interchange of ideas and the contacts and general rounding out of our knowledge of our neighbors in other states has made for a better understanding of their needs.

Such a road as European Highway No. 1 should be termed the European "highway of friendship," which, let us hope, will dissipate the suspicion with which the people of one nation seemingly regard those of another.

# Speed Versus Safety on Curves

*By* R. A. Moyer

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Associate Professor of Highway Engineering, Iowa State College, Ames, Iowa

*When the speed of a car on a fixed curve increases, must the steering wheel be rotated further, turned back towards neutral, or kept in a fixed position? Either the first or second condition obtains, says Professor Moyer, depending upon the design of the car. The slip angles of the front and rear wheels are also important, since in order to stay on a curve at high speed, a car must generally develop side-skid friction. The loss of traction due to uneven road surfaces is another factor. These and other results of a five-year series of investigations for determining uniform speed-control standards were presented in detail in Bulletin 120 of the Iowa Engineering Experiment Station. The following article, which recommends the provision of three classes of highways, each having a frictional factor of safety between 3 and 4, for varying road environments and types of vehicles, represents the second part of Professor Moyer's summary, as presented on July 1, 1936, at the Highway Safety Conference in Ames, Iowa. For other aspects of the general problem, reference may be made to a previous article, which appeared in the December 1936 issue of "Civil Engineering," entitled "Speed Versus Safety on Straightaways."*

When driving a car at low speeds, a driver experiences no difficulty in negotiating curves, but as the speed increases, the difficulty of keeping the car on a fixed path likewise increases until finally a speed is reached at which complete control of the car is lost and skidding or sliding off the curve results. In tests at the Iowa Engineering Experiment Station, cars with favorable operating characteristics on curves and cars known to have difficult operating characteristics on curves were driven at speeds of from 10 to 70 miles an hour on three representative curves. From measurements of steering angles and rear-wheel slippage, the important characteristics of the behavior of these cars on curves were determined.

The results obtained in the measurement of the steering angles proved most enlightening in determining possible causes of skidding on curves. Instead of obtaining a constant steering angle (that is, a fixed position of the steering wheel) on a given curve with cars of the same wheelbase, as one might expect, the steering angles were found to vary considerably with an increase in speed. Variations were also found for the same car, depending on the load distribution and tire pressure used. Three typical steering conditions (Fig 1) were observed.

A fairly common unstable condition was that in which the steering angles increased approximately as the square of the speed until a speed was reached at which a further increase in the steering angle no longer held the front wheels on the curve. For cars with this type of steering control, the front wheels would have slid off the curve before the back wheels if the speed had not been reduced to the point where steering control was regained.

Another and less common unstable condition was that in which the steering angle increased only slightly with an increase in speed up to a certain speed, beyond which this angle decreased approximately as the square of the speed until a speed was reached where a further decrease in the steering angle no longer kept the car on the curve. In this case the rear wheels tended to slide off the curve first, and if the driver had not anticipated this action, the car might have gone into a spin and rolled over. This is probably the most hazardous steering condition because the average driver is likely to lose control of the car once the rear end starts to skid.

The most nearly stable condition is obtained when the steering angle increases with an increase in speed to a point where the ride is so uncomfortable that the driver logically expects the front wheels to slide off the curve, as they must at some speed. In this case the critical speed is much higher than in the other two cases. Here again, a reduction of speed will permit the driver to regain control of the car. There are many factors which cause variations in the steering angles. The control of these factors lies largely in the hands of the motor-car manufacturers, who are now developing designs in which steering control is greatly improved.

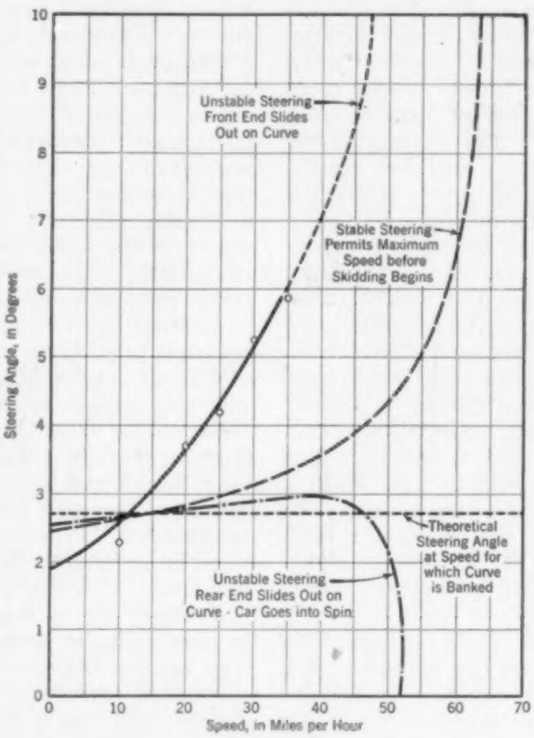


Fig. 1. Three Typical Steering Conditions Developed in Driving Cars Around a 28-Deg Curve

### Wheel Slippage and Slip Angles

When a car is moving on a curve, a centrifugal force is set up which tends to cause it to slide off. To counteract the effect of this force, highways are banked on curves and a gravity force is introduced which opposes centrifugal force. The centrifugal force increases as the square of the speed, while the gravity force on a given curve is the same at all speeds. Therefore, there is only one speed at which these two forces are exactly balanced. A car traveling slower than this speed will tend to slide towards the inside of the curve, and a car traveling faster will tend to slide towards the outside. These characteristics are quite evident when the road surface is slippery. Under such a condition drivers will generally proceed at a speed slower than that for which the curve was banked, with the result that the car slides towards

the inside of the banked section. Curves on highways in sections where ice forms should not be banked steeper than one in ten.

Because of friction between the road and the tires, if speed is not excessive a turn can be made safely on a flat surface where no gravity force is available to counteract centrifugal force. When driving at the speed for which a curve is banked, no friction is necessary to resist skidding sideways, and both the front and rear wheels occupy their normal position with respect to the path of the car. This condition is shown in Fig. 2 (*a*). However, when friction is necessary to keep the car on a fixed

*Indianapolis Motor Speedway Corporation*

BACK WHEELS TRACKING OUTSIDE FRONT WHEELS ON IMPROVED INDIANAPOLIS SPEEDWAY CURVE

curved path, both the front and rear wheels must be turned at angles with the line of travel Fig. 2 (*b*). These angles, which are known as slip angles, provide the necessary side thrust in the form of friction between the tires and the road to counteract centrifugal force. This frictional force also permits rounding a curve at a speed considerably greater than that for which the curve is banked.

Since the positions of the rear wheels are fixed with respect to the body of the car, it is necessary to slide the entire rear end of the car out on the curve as the speed is increased, in order to develop the slip angle and the friction required. This position is particularly evident when racing cars round curves. The rear wheels in such cases swing several feet outside of the front wheels and develop large angles with the line of travel. The average driver can easily visualize a racing car skidding or sliding around a curve, but does not realize that his own car takes a curve in a similar although less extreme way.

A significant feature of the slippage tests is the magnitude of the slippage as the speed of the car is increased. The trend indicates that the slippage at speeds of 80 miles an hour or more is so large on curves sharper than 3 deg that the most skillful driver will have difficulty in steering the car and holding it within a 10-ft traffic lane.

The most hazardous situation when driving on a curve at moderate speeds develops when the surface is slippery, particularly when it is wet, or covered with mud, snow, or ice. Tests on these surfaces indicate that when a certain critical speed is reached, the friction necessary to keep the car on the curve changes very suddenly, with the result that the car starts to skid. It is this sudden change in frictional resistance which the average driver fears. Actually a certain amount of friction is still available, and skidding on a curve should be hazardous only in cases where the driver enters the curve too fast or where the slippery condition develops suddenly. Unfortunately, many drivers step on the brakes from force of habit as soon as the skid starts. Instead of stopping the skid, this is likely to make it worse.

While skidding is generally caused by driving at speeds excessive for a given road condition, it is better controlled by use of the steering wheel and throttle, rather than by an attempt to reduce speed suddenly. Applying the brakes creates an unstable rear-wheel condition, whereas use of the throttle produces a driving force at the rear wheels which counteracts centrifugal force and has a steadying effect on steering. When going into a curve, racing drivers have shown that braking will cause the rear wheels of the racing car to skid outward and get the car turning in the direction of the curve faster than if a uniform rate of speed were maintained. The skillful racing driver swings his rear wheels out by an amount such that he can "gun" the motor somewhat sooner, and the accelerating force which is thus created controls the rear-wheel skid and brings the car off the curve at a correspondingly higher rate of speed.

The majority of accidents on curves are caused by entering the curve at an excessive rate of speed. If the driver can get the car safely on the curve, he should have little difficulty in steering around the curve, particularly if he can keep a steady foot on the throttle and have the benefit of a driving force to counteract at least a part of the centrifugal force tending to pull the car off the curve.

### PATH OF A CAR ON A CURVE

Until recently all curves on highways and turns at street intersections were designed as simple arcs of circles connecting two tangents. However, speeds have now increased to a point where drivers are experiencing difficulty in steering around such curves. Here the difficulty arises in changing the direction of travel from a straight line to a fixed curved path, as it is impossible to change instantaneously from motion in a straight line to motion in a curve of fixed radius.

In making the change from tangent to fixed curve, the highway engineer should use transition curves, as has been done on railroads for many years. Transition curves have uniformly varying radii, permitting the driver to change the position of his steering wheel gradually until a fixed position is reached at the beginning of the circular curve. At moderate speeds the average driver can develop a transition curve within his own traffic lane, but when making a turn at a speed higher than that for which the curve is designed, he is likely to get into trouble. This is particularly true at street intersections designed in the horse-and-buggy days [Fig. 3 (*a*)], where drivers frequently swing far over into the lane of approaching traffic in making the turn. If the intersection curve were designed with a spiral approach or consisted of a compound curve using 120-ft and 30-ft radii [Fig. 3 (*b*)], this serious traffic hazard would be eliminated.

Another distinct advantage of such a design is that it makes it possible to foresee what type of turn the driver of the car approaching the intersection from some other direction is likely to make. If about to make a right turn, he would be expected to keep the car close to the curb; if going straight through, to keep the car in the center lane; and if making a left turn, to start turning from the center of the road before entering the main part of the intersection. Practically one-half of our traffic accidents occur at intersections, and it is the uncertainty of traffic movement which makes such points so hazardous.

A study of the way racing drivers handle their cars is also useful in determining critical speeds on curves. The margin between victory and defeat lies largely in the speed possible on the curves and the skill of the driver. On the Indianapolis Speedway, speeds on the curves vary from 90 to 100 miles an hour as compared with 120 to 130 miles an hour on the straightaway, whereas

on the usual dirt track the speeds on curves range from 40 to 60 miles an hour and 70 to 90 miles an hour on the straightaway. Racing drivers take the curves as fast as possible and the margin of safety is very small.

Probably the phase of driving on curves which requires the greatest skill is the ability to change from a straight line to a fixed curve in the shortest possible time and with the least amount of weaving. This is best measured by the rate of change of acceleration when entering the curve. It is significant that the maximum rates of change of acceleration obtained on the Indianapolis Speedway are in close agreement with those obtained on the dirt track at the Iowa State Fair Grounds at Des Moines, varying from 5 to 6 ft per sec per sec per sec. If such rates provide only the low factor of safety in use among racing drivers, it would seem that the spiral transition curves for use on highways should be designed with a factor of safety at least three times as great, or a rate of 2 ft per sec per sec per sec.

The same safety factor may be obtained, of course, by reducing speed. It is surprising to discover how small a reduction in speed is necessary to provide a sizable factor of safety. Thus, on a curve on which a racing driver might drive 60 miles an hour, reducing the speed to 40 miles an hour would provide a factor of safety of 3. But just as a reduction in speed will increase the margin of safety, so an increase in speed will rapidly decrease the margin of safety to the vanishing point. This is one of the deceptive characteristics of speed which even the most skilled drivers have difficulty in sensing. When increasing the speed from 70 to 80 miles an hour, the changes in the behavior of the car are far different from those in accelerating from 30 to 40 miles an hour.

The time is rapidly approaching when we can no longer depend on the driver's judgment in regard to the deceptive effect of speed. Quiet, smooth-running cars have greatly contributed to this deception, and one of the pressing problems confronting automotive and traffic engineers today is that of devising methods whereby the driver can be kept continually conscious of the speed at which he is traveling and the requirements which he must meet in bringing the car to a stop or in making sharp turns.

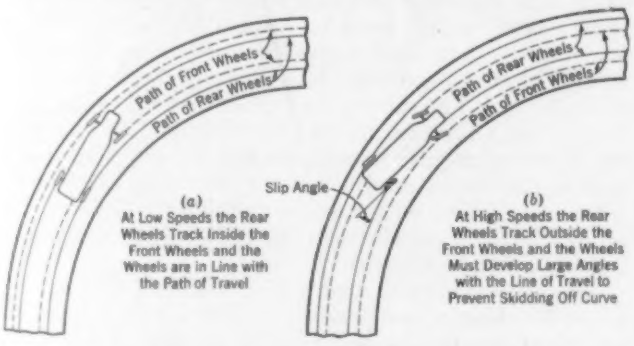


FIG. 2. ILLUSTRATING THE EFFECT OF SPEED ON THE POSITIONS AND PATHS OF FRONT AND REAR WHEELS ON CURVES

(a) At Low Speeds, a Car Requires No Side-Skid Friction to Stay on a Given Curve

(b) At High Speeds, Side-Skid Friction Must Be Developed by Both Front and Rear Wheels

#### EFFECT OF SURFACE ROUGHNESS ON CONTROL OF CAR

Roughness or waviness of the road surface will greatly reduce the available friction between the surface and the tires as the speed of the car is increased, because uniform contact between the tires and the road surface is not possible under these conditions. The surface roughness or waves will cause the tires to bounce. If the waves are long enough and the speed great enough, the entire car may "take off" after hitting the crest of the wave.

Sir Malcolm Campbell waited for weeks at Daytona Beach for a perfectly smooth surface, since at speeds of about 250 miles an hour, waves in this surface causing a variation of 2 in. in 100 ft (not capable of detection by the eye) were sufficient to lift his 6-ton car off the surface. It was surface roughness that made it impossible for him to drive at 300 miles an hour at Daytona. His ambition to drive at this speed was only achieved when he drove his car on a lake bed of salt which was perfectly level. The "Bluebird" had large fins to help steer it. It is interesting to know that at 300 miles an hour the tremendous friction caused a blowout and burned up the tires in one trip of 12 miles.

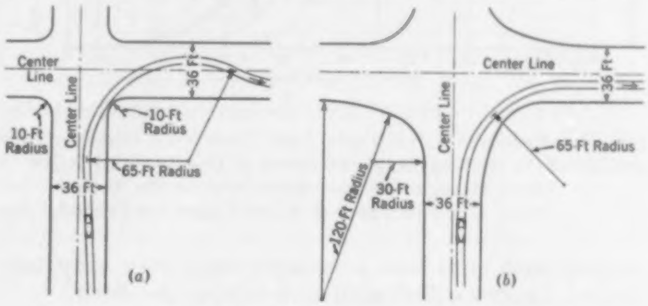


FIG. 3. PATHS OF CARS MAKING TURNS AT INTERSECTIONS

(a) Typical Existing Intersection with Short-Radius Curve

(b) Proposed Intersection with Compound Curve

Before its reconstruction, the slight surface waves on certain sections of the Indianapolis Speedway were sufficient to lift drivers out of their seats and to raise cars off the surface at speeds of 100 miles an hour. Under these conditions the skill of the driver was taxed to the limit in maintaining control of the car when it landed. It is possible that this surface roughness contributed largely to the death of 27 drivers and mechanics.

The significant point here is that these drivers were among the most skillful in the country, driving cars in excellent mechanical condition on a track 60 ft wide. Yet today thousands of drivers try to drive at speeds of 70 to 80 miles an hour on curves of the same radius on our state highways with traffic lanes only 10 ft wide. The fact is, it is impossible to drive at such speeds without greatly endangering other traffic. To make speeds of 80 miles an hour safe for even a selected group of drivers will require smooth road surfaces, curves with spiral approaches, and roadways on which all passing and crossing hazards are eliminated. There is no road in this country of any considerable length which can meet these specifications, and until such roads are constructed, driving at the top speeds of cars as now produced is highly dangerous.

It is true that there are long stretches of straight road in the West and Middle West where the danger is not so great as in the more congested areas of the East, but a speed of 80 miles an hour is very deceptive and few drivers realize the dangers involved. Even on a good road surface, with excellent brakes, an expert driver operating at 80 miles an hour cannot stop the car safely in less than 500 ft after he first recognizes the danger, or if he desires to overtake a car traveling 70 miles an hour in the face of another car approaching at 80 miles an hour, a clear space of at least one-half mile is necessary. Many drivers are prone to take a chance by passing the car ahead when the clear sight distance is less than this,

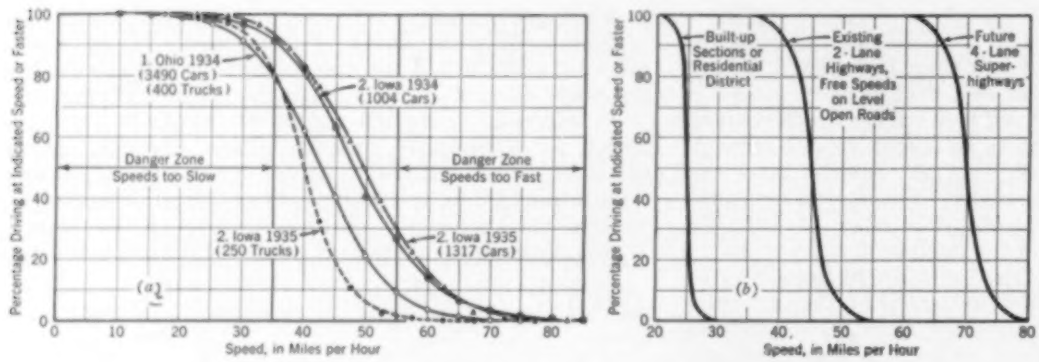


Fig. 4. Existing and Proposed Speed-Distribution Curves

(a) Free Speeds on Level, Open Roads Now Vary Widely. Curves Marked "1" Are Taken from the *Proceedings* of the Highway Research Board as Developed by Bruce D. Greenshields, Assoc. M. Am. Soc. C.E. Those Marked "2" Were Developed by the Author. (b) Curves for Various Locations and Types of Roads Under the Proposed Speed-Control System

cutting back into line so sharply that they may lose control, cause a collision, or turn over in the ditch.

### FACTORS OF SAFETY IN DRIVING AS AFFECTED BY SPEED

Engineers are accustomed to build structures with a factor of safety consistent with the risk of failure involved. Yet in highway safety work, engineers are very prone to determine safe driving speeds without any regard for a factor of safety. Records of automobile accidents indicate that driving cars with little or no factor of safety is certain to lead to dire consequences. Traffic engineers and drivers should recognize the fact that the law of averages holds true and is as certain to be enforced as the law of gravity. The factor of safety should be raised by eliminating hazardous road surfaces, by improving the braking and steering mechanisms of cars, by educating drivers and making them speed-conscious, and by standardizing speeds by zones so that drivers will be fully aware of the safe speed in each.

To promote the greatest safety, a uniform speed for all vehicles in a given zone or location is a guiding principle which traffic engineers should always consider when solving problems involving speed. Many accidents could be prevented if this principle were carried out in the control of traffic. The continual overtaking of cars on two-lane highways, together with excessive use of brakes and accelerator, leads drivers into all kinds of braking and steering difficulties. The present variations in highway speeds shown in Fig. 4 (a) illustrate the nature of this problem. Speed variations of from 20 to 80 miles an hour are common today on all rural highways. It is interesting to note that on open, level stretches of road, truck speeds are not very much lower than car speeds. Our tests indicate that it should be possible to build trucks with stopping ability on level grades very nearly equal to that of the average passenger car. The low-speed hazard created by trucks, largely confined to grades steeper than 3 per cent, can best be eliminated by building 4-lane highways on such grades.

The speed-distribution survey studies indicate that the safety of a large volume of traffic is jeopardized by about 10 per cent of the traffic operating at speeds under 35 miles an hour and by another 10 per cent operating at speeds above 60 miles an hour. If traffic could be regulated to maintain uniform speeds of about 45 to 50 miles an hour on open, level stretches of road, many of the hazards created by our present lack of a speed-control plan would be eliminated. A similar speed-control system should be provided on curves, in built-up or residential districts, and also in a possible future 4-lane superhighway development. The speed-distribution curves under such a plan would then appear as in Fig. 4 (b).

With rigid motor-vehicle inspection, drivers' examinations, and an efficient motor patrol, speeds of 45 to 50 miles an hour should assure a reasonable factor of safety on our present main highways. Hazardous sections of road should be marked by signs indicating the safe approach speed to the nearest 5 miles an hour. The maximum safe approach speed on a given curve may reasonably be established as that speed for which a useful coefficient of friction to counteract centrifugal force shall not exceed 0.10 according to the formula, $V = \sqrt{15R\ (f + e)}$, where $V$ is the maximum safe speed in miles per hour, $R$ is the radius of the curve in feet, $f$ is the coefficient of friction (use $f = 0.10$), and $e$ is the superelevation of the roadway in feet per foot.

### FUTURE HIGH-SPEED HIGHWAY DEVELOPMENTS

In regard to possible future superhighway developments for high-speed travel, this investigation indicates that it should be possible to build highways and cars which would make possible safe maximum speeds of 80 miles an hour for a selected group of drivers. However, the cost of such highways might prove to be prohibitive, since right-of-way widths would have to be increased to 200 ft or more. Traffic would be segregated in two two-lane roadways, one for each direction, with parting strips possibly 50 ft wide between them. Access to these roads would be at intervals of 10 to 50 miles only. No highway or railway crossings at grade would be permitted. The road surface would have to meet a higher standard of smoothness than that provided on existing roads and would have to provide a uniformly high resistance to skidding. The curves and grades would be designed to provide a uniform factor of safety of 3 or 4 to meet the frictional requirements for operating at the maximum permissible speed established for this class of highway. There would then be no sudden shifts in the design standards or in the slipperiness of the road surface demanding sudden changes in speed.

There are many factors which indicate that it may prove far cheaper and possibly equally safe to take to the air when speeds above 60 miles an hour are desired. This was forcibly demonstrated in the 1935 speed-record runs, in which a 2,500-hp motor was required by Sir Malcolm Campbell to average 300 miles an hour on land, whereas only a 1,000-hp motor was needed by Howard Hughes to average 350 miles an hour in the air.

The results of the investigations described in this article, and published in detail in Bulletin 120 of the Iowa Engineering Experiment Station, should provide much of the basic information for determining the speed-control standards so urgently needed today. Design engineers, traffic engineers, and traffic officials can render a valuable service in the promotion of highway safety by reaching some agreement in regard to reasonable speed-control standards for the various road and traffic conditions. Further delay in establishing uniform standards will be costly in life and property, and will certainly lead to additional complications.

# Draining the Great Fens

*And an Account of Road Construction by Thomas Telford in Scotland and Wales*

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*Among the greater achievements of Thomas Telford must be counted his work in draining the Fens in the east of England, 1818–1830; constructing a system of roads in Scotland, 1803–1821; and reconstructing a road across Wales from Holyhead to Shrewsbury, 1815–1819. As Telford was 58 years of age at the close of the Napoleonic wars in 1815, these works are all products of his maturity. He was the first to put into effect a rational and effective method for draining the Fens; in constructing highways in the Scottish Highlands, he fathered our present system of carrying out public works by contract; in relocating and reconstructing the Holyhead-Shrewsbury highway, he provided for the first time what may be called adequate modern road foundations, including the stone base which still bears his name. The following interesting account of these activities is abstracted from the third of a group of four lectures on Telford's life and works given by Professor Baker at the University of Bristol. The preceding articles appeared in "Civil Engineering" for November and December 1936, respectively.*

IN any discussion of Thomas Telford's work with waterways, something should be said of his activities in the Fen country. The tract of country so aptly named "The Great Level of the Fens" extends over some 60 miles north of Cambridge, varying in width from 20 to 30 miles. In Fig. 1 its principal features appear in moderate detail. Its general location is shown on the small-scale map, Fig. 2. From the remote ages, this area has exercised a strange fascination for man—partly perhaps because its story is one of a continual fight to make the greater part of the region habitable.

With an elevation only slightly above sea level, and in some parts even below that level, the land has been flooded both by inland water and the sea. Sea banks, cuts, and drains everywhere intersect its surface. The Fen country receives within its boundaries the flow from the Witham, Glen, Welland, Nene, Cam, Great Ouse, Lark, Brandon, Stoke, and Wissey rivers, but its only outlet is the sand-encumbered estuary of the Wash. It is not surprising that great difficulty is encountered in getting rid of the surplus water.

It is necessary to emphasize that the flooding has been due mainly to inland water, backed up by the tides, and that only on occasion has the sea been directly responsible. As a result, a deposit of rich alluvial matter has been left by the slow-moving waters, and soil of great agricultural value has gradually accumulated.

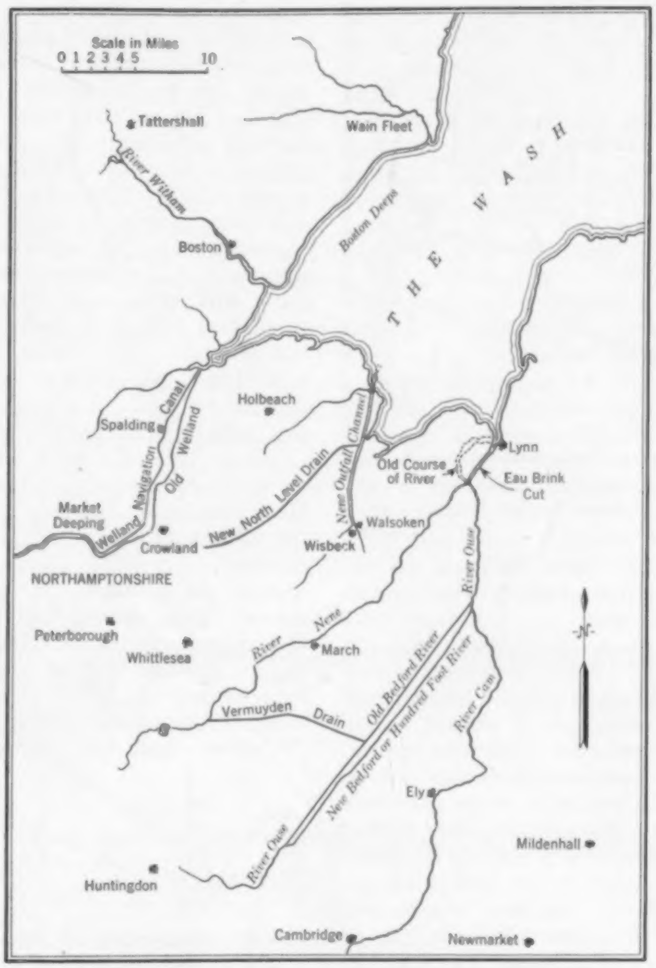


Fig. 1. Sketch Map of the Great Fens District

The reason for the building of the early banks at the sea edge, reputed to be of Roman origin, can only be surmised. However, it is known that later the Saxon monks, in search of solitude, built their monasteries on higher points such as Ely, Crowland, and Boston and, in the course of time, gradually enlarged their boundaries by embankment and drain. Other inhabitants did likewise, and in so doing encroached at times on the dikes and drains of their neighbors. Thus began the long series of disputes and controversies that form such an outstanding feature of the history of the region.

The dissolution of the monasteries by Henry VIII proved disastrous to the Fen country. By this act Henry not only removed from the soil some of the best agriculturists of all time, but also confiscated wealth. Thereafter there was no money to maintain the waterways and banks, and in many places the Fens returned to their original state.

#### Transport in the Fens

Water transport, always the main means of communication in these parts, had been well developed during the Middle Ages. The ports of Lynn, Boston, and Wisbeck had been in direct contact with Ely, Cambridge, Lincoln, and Peterborough, while other towns and villages were also served. Neglect of the waterways seriously affected the trade of these ports. In consequence petitions were presented to the government and, during

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Elizabeth's reign, several acts to improve the drainage of various parts of the Fens were obtained. However, the first attempts under the new acts ended in failure. The banks broke and serious flooding took place.


FIG. 2. MAP OF GREAT BRITAIN, SHOWING LOCATION OF THE FENS AND THE HOLYHEAD-SHREWSBURY ROAD

After a time help was sought from Holland, on the assumption that conditions in that country were similar to those in the Fens. As the result of an inquiry held at Lynn in 1631, Vermuyden, a Dutchman, was appointed to carry out the work. Vermuyden, influenced by his experience in Holland, acted on the assumption that the sea was the great enemy which should be excluded at all costs and, to that end, built sluices and gates to keep the tide from penetrating so far inland. It is even asserted that his cuts tended to reduce the rate of flow of inland water to the sea. This policy was in direct opposition to that previously pursued, in which the flow of the tide in the main rivers had been encouraged as an aid to navigation, and land drains had been arranged to provide runoff at low tide. In spite of some understandable difference of opinion as to the wisdom of Vermuyden's policy, his influence on the Fens was profound, and in many places the sluices stand today just as he placed them.

Although Vermuyden's efforts greatly increased the cultivable area and stimulated interest in further improvements, unexpected troubles soon arose. The diversions had allowed old channels to silt up, and the sluices, by preventing free tide action, left only the inland water to scour the channels. Except during heavy rainfall, the flow proved inadequate for that purpose, and complaints continued for the next 150 years.

From the foregoing brief survey some inkling may be gathered of the problems and difficulties facing Thomas Telford when, in 1818, he was invited by the commissioners of navigation of Lynn to act for them in the proposed improvement of the outfall of the river Ouse. For the next twelve years Telford was concerned with a number of schemes for improving the drainage in various parts of the Fens. Most of this work was done in association with one of the two Rennies and with the contractors, Jollife and Banks. Telford's reputation as an engineer was enhanced by his experience in the Fens, but he must have found it difficult to accustom himself to practices in a region where the technique of building embankments had become a tradition of a high order.

The form and dimensions of these banks were no doubt determined by the material available. As the earlier banks were usually built of silt excavated from the cut, augmented by that obtained from borrow pits, it is not suprising that breaks were frequent. Many of these old banks were later opened up in the center, and a gault or puddle core inserted. This established the practice of constructing banks so that the puddle core effectively seals the center portion.

Another important precaution was the provision of a natural-level foreland or berm, extending from the edge of the cut to the inside toe of the bank, as shown in Fig. 3. The width of this foreland, which was designed to prevent subsidence into the cut, was determined by the nature of the soil. The main constituent of the Fen soil is silt, which is often superimposed on a layer of peat or soft blue clay. As the latter materials readily form cleavage lines, the importance of the foreland is at once apparent. The dimensions of the New Bedford River bank will serve as an illustration of the size of a major work and will give some idea of the labor involved in construction. This bank measures 60 ft at the base, is 8 ft high, has a slope of approximately 1 in 3, and is 10 ft wide on top. A feature of the Fen banks is the flat top, which is commonly used as a cart track.

When Telford's work in the Fens began, no bridges or other structures of magnitude were contemplated. He was asked to appraise the effect of previous engineering efforts on the whole course of the river and on the channel. Applying engineering principles to the solution of the problem, he opposed the Vermuyden tradition and recommended giving sea and tide free access to the main channels. He believed that the ebb tide, aided by the normal flow of inland water which would have been backed up, would scour out the channel and thereby increase the rate of flow at low tide.

Telford and the eminent engineer, John Rennie, Sr., who had built the old Waterloo Bridge, were now appointed to divert from its circuitous course that part of the river Ouse lying between the vil-

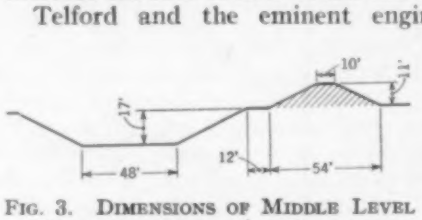



FIG. 3. DIMENSIONS OF MIDDLE LEVEL DRAIN AND BANK NEAR OUTFALL, SHOWING 12-FT FORELAND

lage of Eau Brink and the port of Lynn and give it a more direct line. A cut across the loop of dimensions, such as it was believed would ensure clear channel and prevent the deposit of solid matter, had already been decided upon prior to Telford's appointment. Telford, however, decided that the cut was too small for its purpose and eventually had its size increased by a third. The whole scheme proved successful. As the channel to the sea was deepened a marked increase took place in the flow of the various drainage outfalls.

### IMPROVING THE OUTFALL OF THE NENE

Telford's success with the Eau Brink cut confirmed his opinion as to the importance of tidal action. He also believed in the value of providing artificial river channels more direct than the natural ones. As a result of this success the town of Wisbeck asked his advice on a scheme for improving the outfall of the river Nene. John Rennie, Sr., had previously suggested diverting the Nene some distance to the left of Wisbeck. Telford's proposals did not meet with the approval of the town authorities, and the scheme was dropped for a time. After Rennie's death, his son, John Rennie, Jr. (who was afterwards knighted), and Telford produced a plan for dealing with the outfall below Wisbeck.

Accepting the original proposals, in so far as they concerned the cuts to be made and the general line of the discharge through the sands to the sea, Telford abandoned the proposed sluice gates and boldly allowed the tide free access. The success of the undertaking fully justified the risk involved and again demonstrated the soundness of Telford's reasoning. It is of interest to note here that the maximum gradient of the river bed which could possibly be obtained amounted to only 4 in. per mile.


Fig. 4. Sketch Map of Holyhead-Shrewsbury Road

As soon as the work of the Nene outfall was completed, Telford was entrusted with the survey of the North Level. At various points along its course the main drains of the North Level discharge into the Nene. These drains had been constructed with their sills at the original level of the river, which later raised its bed so that pumping had become necessary. With the improved condition of the river, however, it was believed possible to lower the sills from 4 to 6 ft, according to their position. After a survey of the area Telford was confident that it would be possible so to rearrange the drains and lower the sills at their point of discharge into the river, that the greater part of the land would be drained by gravity.

Telford began work in 1830. Again his operations proved highly effective; the draining of the North Level was a great success, and continues to be so to this day. Before the project was begun, thirty windmills and one steam engine had been required to work the pumps in one district. Three engines are in regular use today. Although Telford was not alone in his opinion of the right method of draining the Fens, to him alone came the opportunity of actually proving the soundness of his theory.

The Dunkeld Bridge Over the River Tay in Perthshire
Designed and Built by Telford in 1805–1809 as a Part of the Highland Road System

### TELFORD'S PLANS FOR ROADS IN THE HIGHLANDS

In the field of road building, Telford's name has been eclipsed in popular fancy by those of Metcalf and McAdam. Nevertheless, it should be remembered that Telford did much important work of this type, especially in Scotland. In 1802, when presenting his report on the Highlands of Scotland, which had led to the construction of the Caledonian Canal, Telford also directed attention to the lack of proper means of communication throughout the country. At that time, practically the only roads in existence were some six hundred miles of military roads, which had been constructed after the rebellions of 1715 and 1745. At the time of Telford's survey these were sadly in need of repair. Also, they had not been intended for heavy-wheeled traffic, and there were no adequate bridges across the larger rivers.

Telford's report, as considered by a committee of the House of Commons, and in 1803 his proposals for a new system of roads and bridges were adopted. Work began and continued for more than eighteen years. During this period 920 miles of new roadways and 1,128 new bridges were constructed. The new highway system covered a wide mountainous area, which for the most part had no facilities for transport or even wheel tracks. Too often, also, there was no local material available for the work in hand. A study of Telford's methods is, therefore, of considerable interest.

The object of his plan was to open up as large a tract

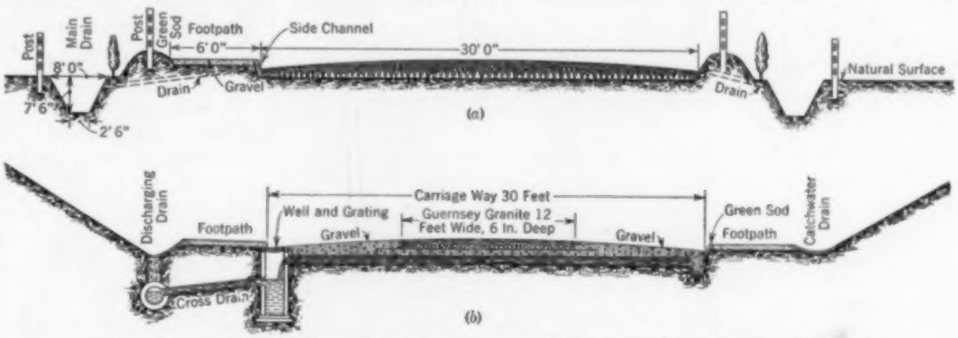



Fig. 5. Typical Cross Sections of the Holyhead-Shrewsbury Road
(a) A New Road with Paved Foundation—"Telford Base" (b) The Highgate Archway Road, Showing Drainage System

THE CRAIGELLACHIE BRIDGE CARRIES THE ROAD BETWEEN ELGIN AND DUFFTOWN OVER THE RIVER SPEY

The 152-Ft Cast-Iron Arch Is a Product of Telford's Road Work in Scotland

of Highland country as was possible with a reasonable outlay of public funds. Advantage was taken of the desire of many landowners to have their property made accessible, by having them subscribe half the expense of the necessary road. Upon receipt of a landowner's application, Telford was empowered to survey the route in question. If this report was favorable, the landowner's subscription was collected at once. Alignment and profile having been fixed, plans and specifications were next prepared, and finally the road was staked out. In the early days Telford directed the field work in person, but later he trained a number of superintendents for that purpose.

After detailed specifications had been completed, contractors were invited to bid, usually for a ten-mile length of roadway. The specifications were strict, giving a clear picture of the roads and allowing little room for supposition. In addition to the road structure, Telford specified in detail the various types of drains to be provided.

Another important provision was for a retaining wall to support the road where it ran on sloping ground or near watercourses. A retaining wall was also to be built where it was necessary to cut on the higher side of the road. The provision for parapets marked a distinct advance in road design in that, for the first time, the safety of the user was considered.

Such comparatively strict specifications probably came as a distinct shock to the contractors, who at first could not realize that they were meant seriously. At the beginning of the work the lowest estimate was usually accepted but experience proved this to be unwise. Telford was, in fact, responsible for our present system of carrying out public works by contract. He introduced the system of investigation of the contractor before making the award, of regular monthly payments, of the retention of definite sums as a guarantee of workmanship and punctuality, and of a period of maintenance during which the contractor is responsible for the state of the new work. As a result of his methods there grew up a body of contractors with a new and higher standard of skill and honesty.

Such a complete system of plans and specifications was unheard of previously, and the £30,000 expended for salaries of inspectors was a small price to pay for the success of this undertaking, which cost approximately £450,000 in all.

Housing the laborers presented no small problem. At first, the men were lodged in temporary huts. However, these proved unsatisfactory, as did the later use of army tents. Finally when sufficient roadway had been constructed to make wheeled traffic possible, a solution of the problem was found in wheeled caravans with space for eighteen men and containing a fireplace. As the work progressed, this was easily moved on, either by horses or in some cases by its eighteen occupants!

## HIGHWAY BRIDGES IN SCOTLAND

An essential feature of the Highlands road system was the construction of 1,128 bridges, of which 11 were unusually large and were in consequence built under separate contracts. The others, including 1,075 with a single arch, 13 with two arches, 16 with three arches, and 2 with five arches, were covered by the road contracts. The design of these structures was naturally governed by local conditions, but in general the larger structures were built of squared sandstone and of iron.

Telford's general specification for bridges related primarily to the smaller type, built of stone set in lime mortar. Where it was possible to do so at reasonable expense, the bridge foundations were to be laid on rock; otherwise, the foundations were to be sunk at least 2 ft below the bed of the river. In soft ground or in places where there was loose gravel, the foundations were to be constructed on a timber platform consisting of 3-in. planks in two layers, at right angles to one another. If the ground proved exceptionally soft, the platform was to be fixed in position by driving rows of piles into the ground around it. When the span was 4 ft, the arch was to rise 1 ft 6 in. and the depth of the stones forming the arch was to be 1 ft. For a 12-ft span, these dimensions were to be 4 ft and 1 ft 4 in.; and for a 50-ft span, 15 ft and 2 ft 6 in., respectively. The roadways between the parapets of bridges were to be flared so that their width would be greater over the abutments than in the center. The parapets were to be at least 18 in. thick, the height varying with the size of the bridge. Where it was necessary to build approaches, stone retaining walls were to be laid up dry for a distance of 60 ft from the bridge. In all cases where the foundations were not built on rock, stone curtain walls were required, extending 35 ft above and below the bridge.

Of the 11 more important bridges in the Highland road system, the largest spanned the river Tay at Dunkeld in Perthshire. This structure replaced a ferry, which had been a slow, inconvenient, and often dangerous means of transportation. With the financial assistance of the Duke of Atholl, whose estate was at Dunkeld, Telford designed a fine, five-arched stone bridge. Of these arches one had a span of 90 ft, two of 84 ft, and two of 74 ft. At either end there were two additional land arches of 20-ft span. The two center piers were 16 ft thick, and as the bed of the river was gravel, some difficulty was experienced in building their foundations. These were eventually carried down a distance of approximately 8 ft below the river bed where they were protected by piles 15 ft long. The bridges built at Lovat and Conan had five arches, the Wick and Potarch bridges three arches, and the Helmsdale Bridge two.

The Bonar Bridge, which carried the road over the Dornoch Firth, was an unusual type of structure. It consisted of three arches—the first two of masonry, with spans of 50 and 60 ft, respectively, and the third an iron arch of 150-ft span with a rise of 20 ft. The iron arch was made up of four ribs, braced together, which supported by inclined struts a roadway of metal plates covered with gravel. A metal arch of very much the same design and dimensions was used to span the river Spey at Craigellachie, as shown in one of the photographs. The soundness of Telford's design of iron bridges was proved in 1814, when the Bonar arch was

subjected to a tremendous blow from a mass of fir-tree logs and ice without sustaining any damage. Four years later, a schooner was swept against the bridge by a swift tide. Both of the schooner's masts were ripped out, but the bridge remained unshaken.

Telford was employed on the construction of many harbors in Scotland, but this work does not lend itself to general description. Piers were constructed in many places to give additional shelter to shipping, existing harbors were enlarged, and passages were deepened. The report of the commissioners gives details of work done at 23 harbors—from Peterhead, the most easterly port in Scotland, to Kirkwall in the Orkneys, and from Tobermory to Tarbert. In addition, Telford played a large part in the extensive program of church and manse building which was undertaken by the government about 1823, providing accommodations for 22,000 people.

### IMPROVING THE HOLYHEAD-SHREWSBURY ROAD

When one considers Telford's numerous achievements in his native land—the Caledonian Canal, the hundreds of miles of roads and lesser canals, more than a thousand bridges, the harbors, and the churches—it scarcely seems possible that he also found time for work in England and Wales. However, in 1810 he began extensive improvements in the route from Holyhead to London, a road which was used several times a year by the Irish members of parliament in traveling between their constituencies and Westminster. Starting from Dublin, the members crossed the Irish Sea in sailing boats. In stormy weather this often required several days, and the passengers disembarked at Holyhead on the unprotected rocks. A rough road, 24 miles long, traversed the Isle of Anglesey to the Menai Straits where, if the Irish Sea had been high, there was every prospect of another choppy crossing. Although the Menai Straits are at certain points only 1,000 ft across, they are nevertheless extremely dangerous. The tide races through the narrow neck at tremendous speed, while conditions are made even more unpleasant by the squalls that chase one another down the sides of the Welsh mountains. Nor, when the mainland was reached, could the perils of the journey be considered over. Between the Menai Straits and the plain at Shrewsbury, there were many miles of mountainous country, where the roads in places were located on the edges of precipices and were unprotected by parapets of any kind. Accidents often happened.

A start had been made on the improvement of this route as early as 1801, when John Rennie, Sr., had carried out a survey to determine the most convenient harbors on the Irish Sea. On the Irish side, Howth, in Dublin Bay, was chosen, and on the Welsh side, Holyhead. The work of providing protecting piers, docks, and landing stages for these ports was started by Rennie in 1808 and continued until his death in 1821. Thereafter these improvements were entrusted to Telford. Together with the introduction of steamships, which took place while the harbors were being constructed, the landing improvements made the first part of the journey safer.

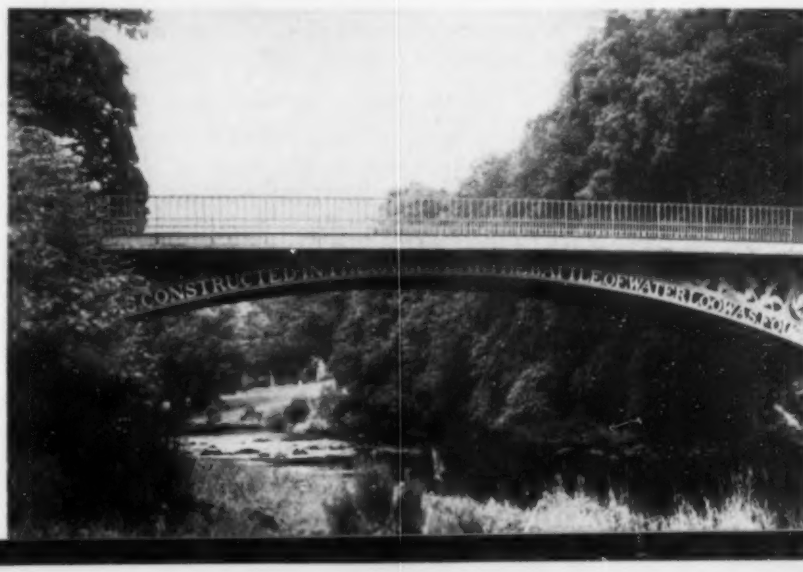
It was soon after Rennie had begun the work of harbor construction that Telford was authorized by the government to survey the ground between Holyhead and Shrewsbury and between Bangor and Chester so that he might be in a position to choose the best route for a new road (Fig. 4). The best route for a road between Shrewsbury and the Menai Straits is along the valley of the Dee, which runs roughly east and west, and meets the Conway Valley extending north and south. Telford suggested a way to save considerable distance by carrying the road from near the head of the Conway Valley by way of Capel-Cerrig and Lake Ogwen to Bangor in the Ogwen Valley. Although he finished his survey in 1811, nothing was done until 1815. In that year, as a result of the efforts of Sir Henry Parnell, member of parliament for Queen's County, a commission was appointed and the work begun.

### THE ORIGINAL TELFORD BASE

Telford, as engineer to the commissioners, organized the undertaking on lines similar to those he had perfected in the Highlands. But the road itself (Fig. 5), which was to accommodate mail coaches, was quite different in construction from those built in Scotland for considerably lighter traffic. It was usually 35 ft wide between fences, 5 ft on one side being used as a footpath, while the remaining 30 ft was carriageway. The bed of the road, for the middle section, usually 18 ft, was fairly level and the natural surface was disturbed as little as possible so that the vegetable mold would form the foundations. Over this area a layer of stones was placed. These stones, which were 7 in. deep in the middle and 5 in. deep at the sides of the 18-ft width, were set by hand side by side. The length of the stones was laid across the road with the broadest edge down. The spaces between the stones were firmly packed with chips, so that a convex surface without local irregularities was formed. On top of this foundation another layer (of smaller stones) was spread to a depth of 6 in. The latter was made up of stones as nearly cubical as possible. Finally a layer of binding gravel was placed on top.

Over the remaining 6 ft on either side of the 18-ft width, earth was spread and consolidated to a level within 4 in. of the finished surface of the middle section of the road. The 4-in. space was then filled in with gravel. This type of road is an improvement over that built in the Highlands, and far more durable. As a matter of fact, it differs little from the practice in road making in Great Britian immediately before the introduction of the modern motor road.

Within four years most of the poorer sections of the mountainous North Wales road were improved and the necessary bridges were built. The smaller bridges were constructed of slate rubble and, as in the Highlands, the larger structures took the form of metal arches resting on stone abutments. The Waterloo Bridge over the river Conway near Bettws-y-Coed is a typical example of the latter. This structure has a span of 105 ft with a rise of 10 ft 6 in., its five ribs being braced together by transverse plates at intervals of about 15 ft. A continuous platform, made of flanged metal plates bolted together, carries the road surface on top of the ribs of the arch. The outer rib is ornately decorated. One of the accompanying photographs shows this bridge with its inscription running from one abutment to the other. While excellent examples of their type, these short-span bridges are not to be compared with the later suspension structures for which Telford is famous.



WATERLOO BRIDGE AT BETTWS-Y-COED

The Inscription on the Cast-Iron Arch Reads "This Arch Was Constructed the Same Year the Battle of Waterloo Was Fought." The Panels Depict Roses, Thistles, Shamrock, and Leek

# Predicting Stages for the Lower Mississippi

## *Explaining the Use of Stage-Relation Diagrams*

*By* E. W. Lane

Member American Society of Civil Engineers

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*"HOW high will the river go?" From Cairo to the mouth of the Mississippi, that question is voiced again and again during those critical spring months when the turbulent waters are creeping steadily upward on the levees that guard the alluvial valley. To every dweller in the lowlands, and to the engineers upon whose alertness the safety of the valley depends, the answer is of vital importance. But is any answer accurate? Can it be given sufficiently in advance to be of value? From a painstaking study of years of record, a method has been evolved that does make such predictions possible. In the present article Mr. Lane explains both its basis and its applications. The modifications required in the vicinity of large tributary streams, and the procedure for determining the gage-lowering due to crevasses, are given special consideration.*

As a result of studies made to determine the probability of floods of various magnitudes on the Lower Mississippi River, a series of diagrams was evolved which it is believed will be found helpful in estimating the stages that will be reached in future floods of this river, and in determining the heights that would have been reached by past floods if the levees had not broken. They may also be used in estimating the effects of flood-control improvements, such as spillways and cutoffs, now under construction on the river. The principles involved are believed to be applicable to many rivers.

Reliable estimates of the probability of a future flood of any given magnitude on the Lower Mississippi cannot be based entirely upon the stages or discharges reached in past floods, since many of these stages depended upon the strength of the levees, which was different in every flood. To put the past floods on a comparable basis, an attempt was made to determine the stages and discharges that would have been reached if there had been no levee breaks. A volumetric step method was first tried, similar to that used in determining the effect of retarding basins on floods, but on account of the labor involved and the lack of complete data, the method was abandoned. A study was then made using stage-relation diagrams, with fair success. The present article gives the method of obtaining the diagrams and describes the various uses to which they may be put.

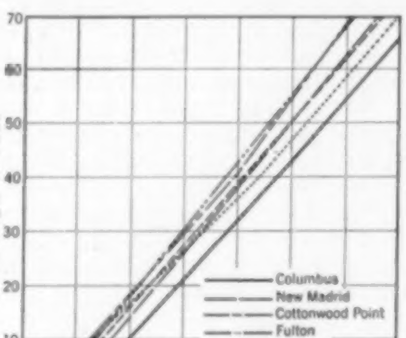



Fig. 1. Stage Relations, Cairo to Mhoon Landing

### SINGLE-LINE STAGE RELATIONS

The simplest form of stage-relation diagram is that containing only two factors, the stage at the upstream gaging station and the corresponding stage at the downstream one. This relation may be represented for any two stations by a single-line diagram. This form is applicable to stations between or immediately below which no important tributary enters. For example, no important tributary enters the Mississippi between Cairo and Mhoon Landing. The stages of the intermediate gages can therefore be predicted by means of curves showing the relation of the stages at these stations. In Fig. 1 is shown such a diagram, giving the stages that would be reached at the gages between Cairo and Mhoon Landing for floods producing various stages at Cairo. For example, the diagram shows that a flood reaching a peak height of 50 ft at Cairo, would reach a peak of 42.4 ft at Mhoon Landing. Of course the peak at Mhoon Landing would occur several days after that at Cairo, as will be discussed later. The diagram also makes it possible to compute the relation between stages at intermediate stations. For example, the stage at Mhoon Landing that would be caused by a flood reaching a 30-ft stage at New Madrid can be determined by first finding the stage at Cairo (37.5 ft) which would cause a 30-ft stage at New Madrid, and then finding the stage at Mhoon Landing (32.0 ft) caused by a flood of this height at Cairo.

To construct Fig. 1, data were plotted for stages reached by past troughs and rises that were not affected by levee breaks. The line showing the relation between

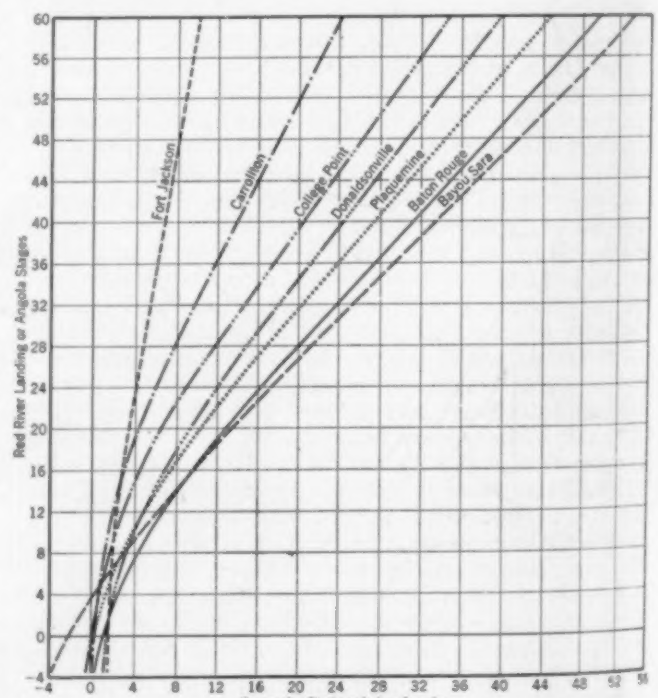



Fig. 2. Stage Relations, Angola and Gages Downstream

the stages reached at Cairo and those at Memphis, for example, is a general locus obtained by plotting the peaks reached by a large number of rises at Cairo against the peaks of the corresponding rises at Memphis, and similarly plotting the minimums reached during a large number of periods of falling stages. In some cases more accurate results may be secured by using separate lines for predicting peaks and troughs. It is probable that the cutoffs below the mouth of the Arkansas may change the stage relations somewhat in the lower end of the reach covered by this diagram, but it can still be used to show the magnitude of these changes.

### SINGLE-LINE AND MULTIPLE-LINE RELATIONS

Below Old River, the gage heights are related to the Angola (or Red River Landing) gage, as shown in Fig. 2.

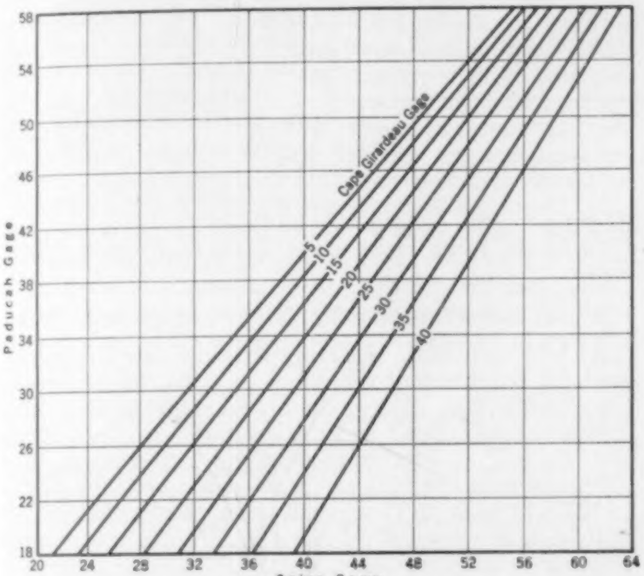



Fig. 3. Cape Girardeau–Paducah–Cairo Stage Relations

In this section of the river the stage relations are very constant, no difference being detectable for confined stages during the period 1905–1927. When crevasses occur, of course, these relations no longer hold exactly. It is probable that the Point à la Hache relief outlet has changed the relations in its vicinity slightly, but its effect will probably not be important. The Bonnet Carré spillway will also cause a change when it is in action.

It will be noted that for river stages corresponding to Angola stages of 30 ft or over, the relations are shown by practically straight lines, but below that point the lines are curved. For zero flow in the river, the lines give gage readings corresponding to mean Gulf level. This is −3.57 ft at Angola and Red River Landing. The lines of Fig. 2 therefore begin at −3.57 ft on the Angola axis and at the various Gulf level readings of the gages for the stations below Angola.

When an important tributary enters the main river, the stages on the tributary must be considered in predicting the stages that will be reached below the junction. For example, the stage of Paducah, Ky., on the Ohio River, and the stage at Cape Girardeau, Mo., on the Middle Mississippi, must both be taken into account in predicting the stage at Cairo, the junction point. This

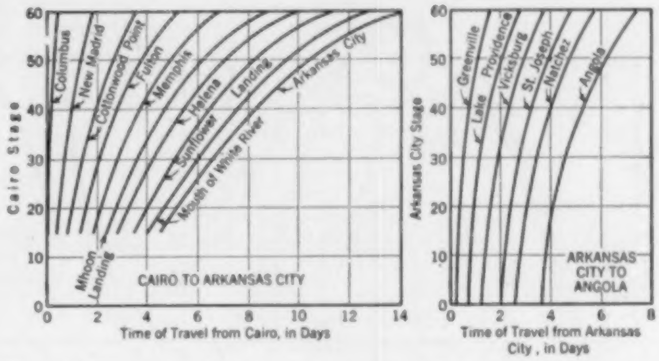



Fig. 4. Relation Between Stage and Time of Travel for Confined Floods on the Mississippi River

gives rise to a multiple-line diagram like Fig. 3. To find the Cairo stage produced by any given stages at Paducah and Cape Girardeau, follow across to the right along the line representing the height on the Paducah gage, to the height in the diagonal-line system (which may have to be interpolated) representing the Cape Girardeau gage, and thence downward to the bottom scale, which will give the height of the Cairo gage the next day.

### TIME OF TRAVEL OF FLOOD PEAKS

In using all these stage-relation diagrams, the time of travel of flood peaks must be considered. This time is not constant between various stations, but differs with the stage, being greater for higher stages. For this purpose Fig. 4 has been prepared, giving the time required for peaks and valleys to travel from Cairo and Arkansas City to the various gages downstream. The time of travel between any two intermediate gages is the difference between the times of travel to the two gages from Cairo or Arkansas City.

This diagram was obtained by readings from another chart on which the time of travel for floods was plotted against the distance of travel below Cairo. On the latter chart each flood was represented by a different


Fig. 5. Actual and Computed Stages at Carrollton for the Floods of 1913 and 1916

line, on which its stage at Cairo was recorded. By means of these lines it was possible to iron out the discrepancies due to the difficulty of determining exactly the day of the peak or valley of the flood, and to the fact that the time of occurrence of the peak was estimated only to the nearest full day. From this time-distance diagram were read off the times required for the various heights of floods to travel to the points below Cairo where the other gages were located, and these times were plotted in the form shown in Fig. 4. Some previous studies had indicated considerably different rates of travel in various stretches of this section of the river, but in the present studies such variations did not appear.

The first part of Fig. 4 covers the river from Cairo to Arkansas City. The effect of floods from the St. Francis River will rarely be sufficient to materially affect the travel time of flood peaks, but the flows from the White and Arkansas rivers are much larger and sometimes entirely alter the travel time below the junctions of these rivers with the Mississippi. Thus in the 1922 flood two peaks came down the river from Cairo, but a large flood came in from the White and Arkansas rivers just between them, and below that point there was only a single peak. For these reasons two diagrams must be used; also, the travel time from Cairo to the mouth of the White River and Arkansas City, as given by the diagram, may sometimes be inaccurate.

The second part of Fig. 4 covers the stretch from Arkansas City to Angola. Here again the cutoffs will change conditions and somewhat affect the travel time, but until sufficient data have accumulated under the new conditions, it will not be possible to tell how great this effect will be.

The Yazoo rarely if ever has a large enough flow to affect the travel time of peaks or valleys. The effect on crest travel of flow through the Old River is probably also negligible. No diagram was prepared for the stations below Angola. In this stretch of the river the crests travel very rapidly; for example, the time from Angola to Carrollton is only about one day.

### USE OF STAGE-RELATION DIAGRAMS

These stage-relation diagrams will be found helpful in making predictions of future stages that are not affected by crevasses, spillway action, or cutoffs; they can also be used to determine the effect of such factors. Because data are not available to illustrate the methods for future cases, past floods must be used as examples.

In Fig. 5 are shown the stages at Carrollton for the 1913 and 1916 floods, predicted from the stages at Angola by means of Fig. 2 and the stages actually attained. The stages for intermediate days are predicted exactly as if they were peaks. It will be seen that the general form of the flood waves in this section of the river can be predicted with considerable accuracy. The agreement is usually not so close on rapidly rising or falling stages as near the peaks. Near the peaks, also, the difference between computed and actual stages is usually relatively constant. These curves represent the results secured by using mean stage-relation diagrams, but closer results can be obtained by an adjustment to represent the relations obtaining for the particular time under consideration, to be described later. In Fig. 6 are shown the actual and computed stages at Cairo during the 1922, 1920, 1916, and first 1913 floods, using mean stage relations without adjustment.

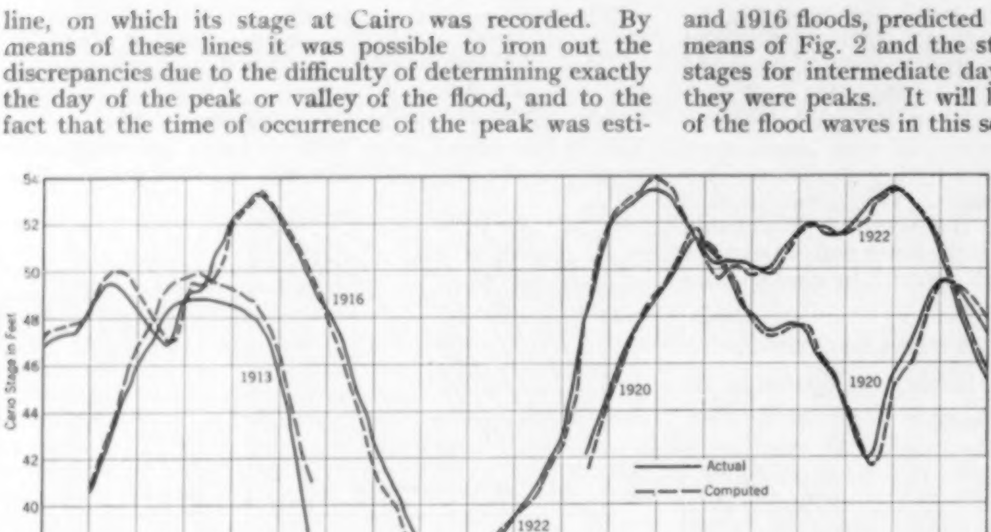



FIG. 6. ACTUAL AND COMPUTED STAGES AT CAIRO FOR VARIOUS FLOODS

### DETERMINING THE EFFECT OF CREVASSES ON STAGES

As has been said, the stage-relation diagram can be used for determining the effect of crevasses on stages. For example, Fig. 7 shows the actual stages at Carrollton during the 1922 flood and the computed confined stages after April 27 as determined from the Angola stage. The difference near the peak of the flood is practically all due to the crevasses at Poydras, a short distance below Carrollton, which opened on April 27. There was another crevasse below Carrollton, but the discharge through it was negligible. The difference between the actual peak stage and the peak stage determined directly by the stage-relation diagram is 1.0 ft. The lowering due to the crevasse was probably greater than this, however, for the stages given by the diagram had been less than the actual stages by approximately 0.5 ft for nearly a month before the break. The peak estimated from the diagram is therefore probably 0.5 ft less than the true peak would have been, and the true lowering due to the crevasse was therefore approximately 1.5 ft.

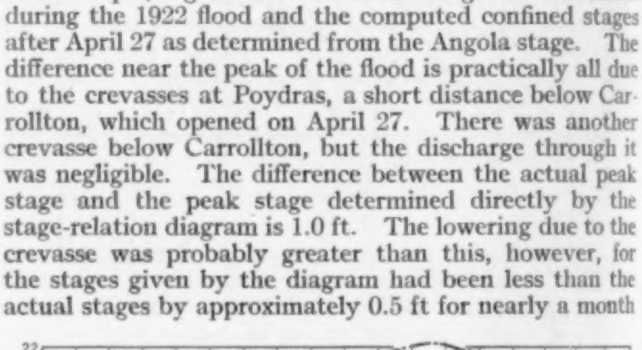



FIG. 7. STAGES AT CARROLLTON DURING THE 1922 FLOOD, SHOWING EFFECT OF CREVASSES AT POYDRAS

In a similar way, lowering of the peak due to the Caernarvon crevasse in the 1927 flood was computed to be 1.8 ft, as shown in Fig. 8. For some time prior to the break, however, the computed stages were 0.2 to 0.4 lower than the actual stages. The 1.8-ft difference is therefore probably 0.2 to 0.4 ft too small, and the true effect is probably 2.1 ft. The lowering that occurred on May 15 is shown in Fig. 8 to be 2.1 ft; with the 0.3-ft adjustment

this would become 2.4 ft, as compared with the 2.0 ft estimated by the Spillway Board (in House Document No. 95, p. 20, 70th Congress, First Session).

In a similar manner, Fig. 3 can be used to compute the effect of crevasses near Cairo. It is also very useful in determining the height that would have been reached there by former floods, and thus enables an accurate estimate to be made of the relative size of floods occurring there in the past. The stages actually reached at Cairo during the 1912 flood are shown in Fig. 9, as well as the stages that would have been reached had no crevasse occurred, as estimated from Fig. 3. The stages predicted a considerable period before the crevasse opened, were 0.4 ft too high, and the peak stages estimated from the diagram should therefore be lowered by that amount.

At Cairo another correction must be made in estimating the effects of crevasses, since a crevasse lowers the stage not only at Cairo but also at both Cape Girardeau and Paducah. As there is no large storage basin in the vicinity of these stations, the lowering may be material. The peak stage estimated by means of the diagram was therefore based on stages at Cape Girardeau and Paducah which were lowered by the crevasse, and hence the resulting estimated stages are lower than they should be. Computations show that a lowering of 0.1 ft would occur at Cape Girardeau for each foot of lowering at Cairo, for the conditions of stage and discharge which are likely to bring about a crevasse. At Paducah, however, owing to the flatter slope and greater depth in the Ohio, the lowering would be about 0.5 ft for each foot of lowering at Cairo.

These corrections are applied by first making an approximate determination of the drop due to the crevasse, by means of Fig. 3, not considering these effects. From this lowering are computed the stages which would have occurred at Cape Girardeau and Paducah if there had been no crevasse, and from these stages a revised estimate of the lowering is made. It will be necessary to make several successive estimates in this manner, each closer than the preceding one, until the effect of the lowering at Cape Girardeau and Paducah is entirely accounted for. In Fig. 9 is shown the result of this correction in the case of the 1912 flood at Cairo. The peak stage actually reached was 53.9 ft. The stage determined from Fig. 3 was 56.5 ft. When corrected by the first adjustment of 0.4 ft previously mentioned, this was reduced to 56.1 ft. Successive adjustments to compensate for the lowering of the stages at Cape Girardeau and Paducah raised this 1.1 ft to 57.2 ft.

### LIMITATIONS OF THE STAGE-RELATION METHOD

A stage-relation diagram gives the mean relation between the stages. It does not take into account the differences due to difference in rates of storage of water in the river itself and in the overflow areas as the surface rises or falls, but gives results for ordinary conditions. Floods which rise more rapidly than usual at the upper station produce a greater rate of storage, and therefore smaller flows and peaks at downstream stations. The reverse is true for slowly rising floods.

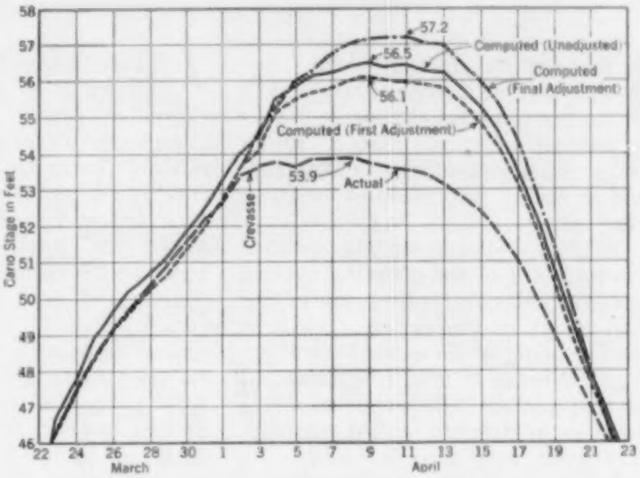



FIG. 9. STAGES AT CAIRO DURING THE 1912 FLOOD, SHOWING EFFECT OF CREVASSE

Since stage-relation methods take no account of variations in storage rate, they are more accurate where the storage capacity is small. For this reason the best results were secured near Cairo and in the reach below Angola, and less satisfactory results were obtained in the backwater basins. It is believed that further study to analyze the effect of different storage rates would develop corrections for the stage-relation method which would make closer estimates possible.

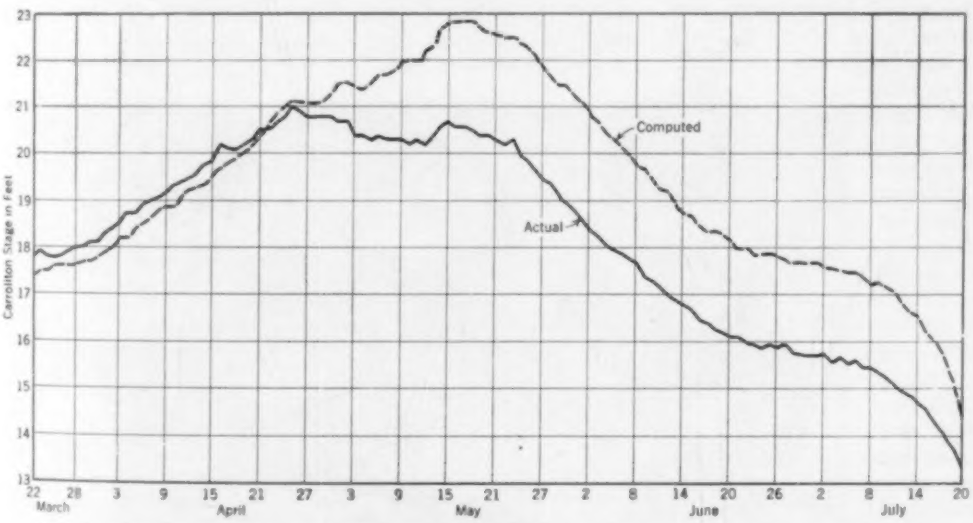



FIG. 8. STAGES AT CARROLLTON DURING THE 1927 FLOOD, SHOWING EFFECT OF CREVASSE AT CAERNARVON

### ACKNOWLEDGMENTS

The development of the diagrams and methods described here was started while I was making the studies for the Mississippi River Spillway Board under the U. S. War Department. These were later continued, aided by funds provided by the late John R. Freeman, Hon. M. Am. Soc. C.E., through the American Society of Civil Engineers. I gratefully acknowledge the assistance received from these sources and their permission to publish the results of the studies. Acknowledgment is also made for helpful suggestions from George R. Clemens, M. Am. Soc. C.E.

# Grouting Contraction Joints at Boulder Dam

*Effective Methods and Equipment Developed for Insuring Monolithic Structure*

*By* James B. Hays
Member American Society of Civil Engineers
Construction Engineer, Chickamauga Dam, TVA, Chattanooga, Tenn.

*In order to avoid cracks resulting from shrinkage of the concrete in its enormous mass, Boulder Dam was constructed in rows of columns whose vertical joints took the place of such cracks. After the fresh concrete had been cooled by circulating refrigerated water, the joints, which had opened wider in the interim, were grouted under pressure, thereby uniting the columns into a monolith. Over 34,000 bags of cement were used in the latter process. In the course of the work Mr. Hays developed some very valuable methods and equipment, whose effectiveness was witnessed by 500 ft of core borings made to cover as wide a range of joint conditions as possible. The work is described in detail in the accompanying paper, constituting the fourth in a group of papers on grouting work at Boulder Dam, of which the first appeared in "Civil Engineering" for September 1936. The present article is an abstract of a much longer paper now on file in the Engineering Societies Library.*

In order to facilitate the construction of Boulder Dam and to confine concrete shrinkage cracks to certain vertical planes, radial and circumferential contraction joints were provided at regular intervals.

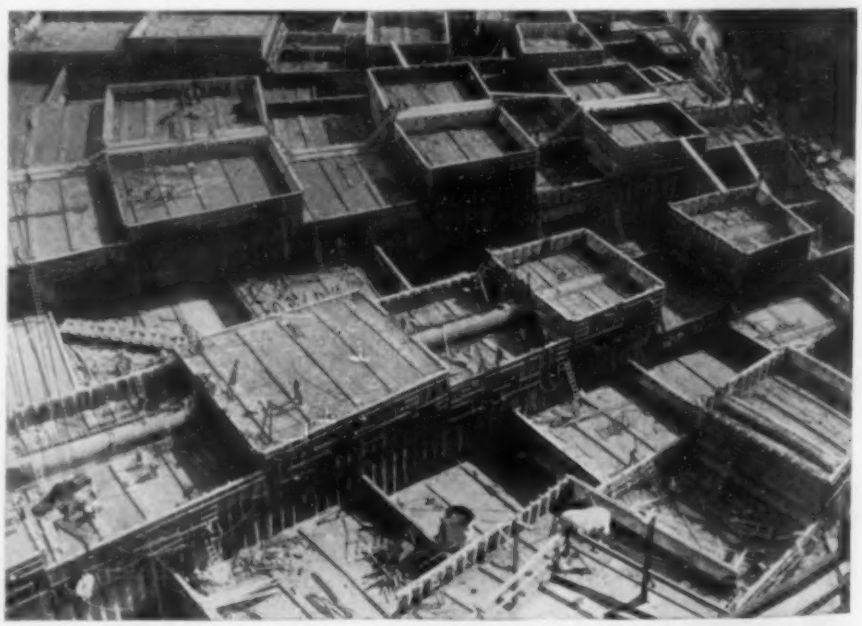
In Fig. 1 is shown the general arrangement of the grouting system at a radial contraction joint. In Fig. 3 (*c*) of the article, "Designs for Grouting at Boulder Dam," by A. V. Werner (Civil Engineering for September 1936), the arrangement at a circumferential contraction joint may also be seen.

As shown in Fig. 1, the contraction joints were grouted in 50-ft lifts. For convenience in grouting and observing the behavior of joints under pressure, galleries were provided at the top of each lift, except near the top of the dam. Between El. 975 and the crest of the dam at El. 1,232, the joints were quite short in an upstream and downstream direction, and the galleries were omitted. Catwalks erected on the downstream face provided the necessary accommodations for grouting.

The radial and circumferential joints were arranged to be grouted separately. The radial joints were continuous in an upstream and downstream direction, while each circumferential joint consisted of a series of joints between two radials. Briefly, the grouting system in each radial joint covers an area 50 ft high and of variable length, depending on the distance of the gallery from the face of the dam (Fig. 2). Each grouting area was isolated from the rest of the joint by copper seals. Below El. 975 all radial joints were divided by vertical seals into upstream and downstream sections. A 1½- or 2-in. horizontal supply header was placed in the concrete parallel and close to each radial joint, 24 in. above the horizontal copper seal. One end of the supply header was brought out to the face of the dam, and the other extended vertically into the grouting gallery at the top of the lift being grouted. At the top of the dam this header extended through the dam from face to face. From the supply headers, at intervals generally of 6 ft, vertical risers of ½-in. pipe extended to a 1½-in. horizontal pipe, known as an outlet or return header, set 18 in. below the upper horizontal copper seal. (A few of the risers came to the surface on the downstream face of the dam.) The risers were connected to grout outlets set in the face of the joints at 5-ft intervals vertically. These consisted of two circular conduit outlet fittings placed face to face, one in each concrete block, so that when shrinkage took place the fittings would separate and permit grout to spread out into the joint.

The circumferential joints were arranged differently (Fig. 3). The supply headers were placed parallel to the supply headers of the radial system, but a 1-in. riser pipe extended vertically towards the top of the lift, at each circumferential joint. Beginning at a point 2 ft above the bottom horizontal seal, ½-in. pipes on 5-ft centers, with grout outlets at 10-ft intervals, extended horizontally from the 1-in. riser across the block to the opposite side, where they joined another 1-in. riser that connected with the outlet header at the top of the lift. At the abutments, where the upstream ends of the joints were beyond the grouting galleries but ended on the rock abutment, pipes known as return vents were installed, extending back to the grouting gallery from the ends of the outlet headers.

The original plans were revised in certain respects



Dam Columns Are in Rows Radially and Staggered Circumferentially
A Radial Gallery Appears in the Third Row from the Lower Right-Hand Corner

The field inspection crew found it more convenient, in testing the grout systems for final approval, to extend the supply headers into the lower galleries on each lift. This was also a convenience in grouting. Another change consisted of installing a second outlet header on the circumferential systems, directly over and connected to each 1-in. riser. This assured the complete grouting of all circumferential joints in a row even though the entrance from the supply header to one or more joints might be plugged. Grout stops were brazed, instead of soldered and riveted as called for on the original plans.

Provision was made for future grouting of the contact between the concrete and the rock on both abutments through systems similar to those used in the joints. Grouting of the abutments will be done at some future date to fill openings that may occur when the dam is under full load.

To facilitate the handling of the cooling-pipe connections, a slot 8 ft wide was left between the *K* and *L* rows extending upstream and downstream through the center of the dam. After the lower lifts had cooled, filling of the slot with concrete was started. No provision was made for grouting the faces of the slot.

Originally, it was planned to grout the joints singly and to complete each one in 30 minutes. However, experience gained just previously in grouting the Owyhee Dam had indicated that group grouting of several joints at the same time was practicable and had certain advantages. Also the filling of joints was necessarily done at a much slower rate than planned, and this made group grouting even more desirable. Group grouting was done by making connections to all supply headers in a group of joints and feeding small amounts of grout to each joint in rotation, by means of separate valves. The grout in the several joints was kept at approximately the same level. By this method, the blocks were better balanced against lateral thrust, and where there were adjacent ungrouted joints, several were filled with water so that at least three or four blocks took the end thrust. Further experience in this work showed that when all the joints were filled with grout, it was desirable to suspend operations for a brief period before applying pressure, to allow the grout in the joints to settle.

An experiment with a glass model arranged to represent the system of piping used in the field clearly illustrated the fact that grout will flow up through the risers more readily than through the joint. This fact, which is very important, determined the methods used in the field, particularly for ascertaining when a joint was completely filled and ready for pressure.

Pressure was used to drive excess water into the concrete, thus further consolidating the grout. Dial gages for measuring the joint opening under pressure were installed in the galleries or on the downstream face. Gages in the gallery at the top of the lift being grouted were watched continually, while those in the gallery below were read occasionally. As a rule the gages recorded a partial closing of the joint after the application of pressure.

Practically all cement used in grouting contraction joints was screened through a No. 200 wire screen and sacked in valve-type paper bags. At first the storage period was limited to 7 days, but this was extended to 30 days after tests had shown that there was no loss of strength or other deleterious effect within that period. The screening rate was much slower than had been anticipated, and the 7-day output plus storage was not sufficient to supply the requirements.

Screened cement was used primarily to penetrate the finest cracks and the narrowest joints. It also had the advantage of remaining in suspension in the grout pipes for a longer period, which reduced plugging of pipes to a minimum and thereby increased the radius of grouting from the mixing and pumping plant. Wear on the grouting equipment was reduced by its use.

### LONG GROUT LINES USED EFFECTIVELY

The success with which grout was handled through long lines may be attributed to the use of thick mixtures, which settled out slowly; the use of screened cement, which remained in suspension for longer periods than regular cement; the proper location of valves; and keeping the grout pipes cool.

The end sections of the grout lines were required

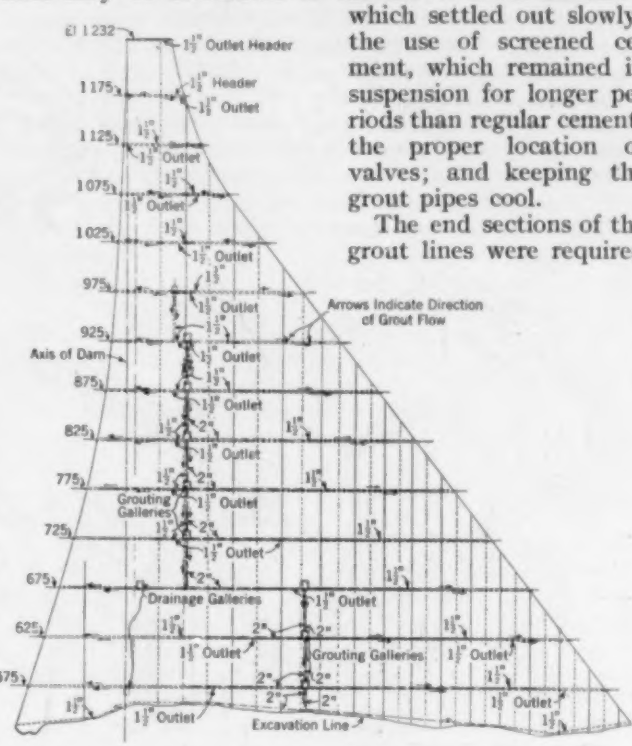



FIG. 1. SECTIONAL ELEVATION OF BOULDER DAM
Showing Grouting System at a Radial Contraction Joint

to hold grout, often under pressure, for periods up to 30 minutes, yet none were ever plugged. The bleeder or blow-off valve at the end of the line would become plugged if not frequently tested, but was never in such condition that it could not be cleaned out readily. The valves at the supply headers were set above the main grout feeder to prevent settling of the grout against the valve. On the opposite end of the valve any hardening grout could be pushed away by the pressure. Gages were always fitted to the top side of the grout line to avoid settling of cement. The usual place for accumulation of cement was at fittings or couplings.

During the summer of 1934, grout lines exposed to the heat of the sun on the downstream face, where the temperature reached 125 F, were covered with sacks and burlap, which were kept wet. In the galleries the temperature ranged from 65 down to 50 F, and there was no need for special protection. The water used in the grout reached a temperature of 80 F during August 1934. This heat was quickly lost in the joints. In a test, water applied through one of the lower radial joints at 80 F was found to be 64 F when it issued from the supply outlet downstream 10 minutes later.

Even when repairs to leaking joints caused long delays, during which no grout was fed into the joint, no plugging resulted. These delays were often considerable, the longest being 2 hours and 41 minutes. While grout

in parts of the joint had no doubt begun to set, the distributing system remained sufficiently free to admit more grout.

### CENTRAL GROUT PLANTS ADVANTAGEOUS

The use of a central mixing and pumping plant proved economical and efficient. The largest estimated saving was in the cement. If cement had been handled in paper bags in the galleries, considerable waste would have resulted, as the galleries were almost always wet, and storage for more than a few hours would have meant much loss. Grouting equipment, particularly the mixer, would have been smaller. Installing the pump in the gallery and mixing at a convenient point some distance away was tried on the first few lifts but showed no particular advantage over the use of a centralized plant.

The advantages of a central plant are

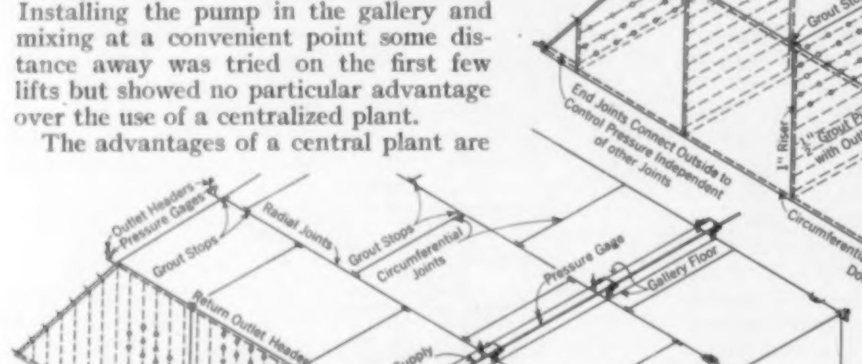



FIG. 2. DIAGRAM SHOWING HOOK-UP FOR GROUTING A GROUP OF RADIAL JOINTS

many. Equipment can be better arranged. More joints can be grouted in a given time. Waste in cement is less and labor costs are lower. The main caution to be observed is to avoid placing the central plant too high. The limiting elevation is that at which the gravity pressure of the grout does not exceed the maximum working pressure desired. If a part of the plant must be at a higher location, the pump and agitator should be located within the limits mentioned.

Certain general rules were established regarding the conditions under which grouting should be done. The total area of a group of joints to be grouted at one time was generally limited to 100,000 sq ft. The slot was filled with concrete to an elevation 50 ft above the top of a lift before grouting. Radial joints were grouted first, and circumferential joints were not grouted until one week after the adjoining radial joints.

The object of the 50-ft rule was to prevent tipping of the blocks in the upper lift due to the use of water to add pressure to grout in joints that leaked and for washing and testing purposes. The rules governing the order of grouting were to give time for the grout in the radials to gain strength and resist the upstream and downstream movement of the blocks in the rows. This resistance in fact restricted movement to the extent that the circumferential joints took approximately one-fourth less grout than the radial joints.

Grouting of contraction joints was done from four different set-ups of the mixing and pumping plant, as follows: From the foundation to El. 675, the 704 gallery; from El. 675 to El. 825, the 780 platform; from El. 825 to El. 1,075, the 975 platform; and from El. 1,075 to El. 1,232, the crest of the dam. In grouting above El. 1,075, the apparatus was mounted on a truck placed near the slot. This portable arrangement was desired by the contractors so that the equipment could be used

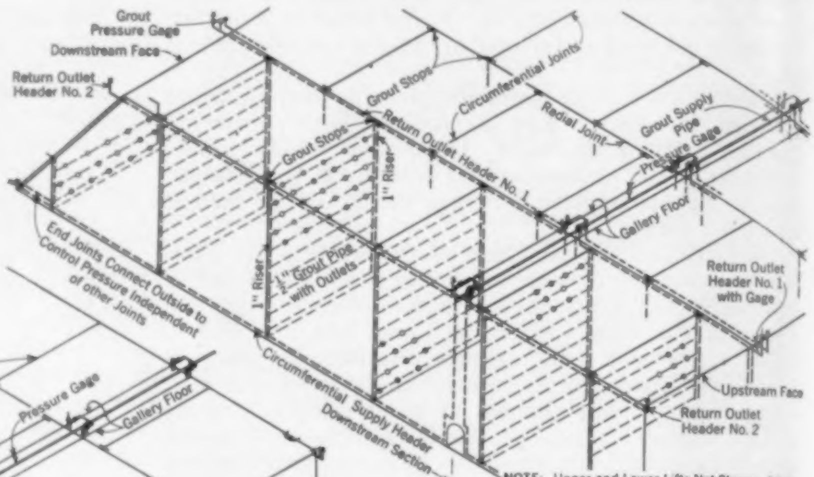



FIG. 3. HOOK-UP FOR GROUTING A GROUP OF CIRCUMFERENTIAL JOINTS OR ROWS

at other points when not required for joint grouting.

Essentially the grouting equipment consisted of a mixer, a water-measuring device, an agitator, and a pump, with the necessary fittings, valves, and piping. The most satisfactory mixer used was fabricated in the shops of the contractor, and embodied many ideas of the author. A detailed description of the grouting equipment, together with a schematic layout, appeared in the article, "Grouting Boulder Dam Tunnels," by V. L. Minear, Assoc. M. Am. Soc. C.E., published in the November 1936 CIVIL ENGINEERING. Only the signal and telephone equipment will be dealt with here.

In order that the operation of grouting a group of joints might be carried on rapidly and effectively, a telephone system was installed. Four phones were required, one at the mixing plant, one in the grout gallery, and one at each face of the dam at the group of joints being grouted. Control could thus be established from each of the important points. A signal light was installed, and as each batch of grout was discharged from the mixer into the agitator, the operator closed a switch that showed a red light in the gallery. When the entire batch had been discharged into the agitator the light was turned off. By this means the grout was measured out approximately in the gallery, where one or more batches were fed into a joint at a time.

One crew of men with but few changes worked with this system of grouting from the start. Many of the men were classed as skilled labor. For the government, one man in the gallery acted as dispatcher, regulating the whole operation, one man at the mixing plant received and transmitted instructions and checked cement and water, one man at each face of the dam kept the "dispatcher" informed as to such matters as the rate of filling

of joints, pressures, and leaks. One man looked after the installation and observation of dial gages across the joints.

The plant, layout, and crew operated in a very efficient manner. A maximum speed of 240 sacks of cement per hour was attained, while an average of better than 200 sacks per hour was maintained for a full shift. The routine which will now be described was developed as a result of experience gained in grouting the lower lifts and was followed thereafter.

#### EFFICIENT GROUTING ROUTINE DEVELOPED

When all connections had been completed, the joints were filled with water and allowed to soak overnight. Just before grouting, the water was drained out and the signal and telephone systems tested. The grout line was tested for leaks under a water pressure of 100 lb. Grouting was started with a water-cement ratio of 1.00. (All mixtures are by volume.) As soon as the agitator was full, the pump was started, and from then on the signal system in the gallery indicated each batch that was pumped. A batch with a water-cement ratio of 1.00 usually consisted of 4 bags of cement and 4 cu ft of water. Thicker batches were based on 5 bags of cement.

The number of batches placed in each joint depended on the relative areas of the joints in the group. The first valve (upstream or downstream, as the case might be) was opened, and at the end of the required number of batches (as indicated by the signal light) the second valve was opened and the first one closed. This method of feeding grout to the joints was continued in rotation unless or until some cause was given for changing the routine. After one or two rounds, the grout mixture was changed to a water-cement ratio of 0.70 for the radials, or to 0.80 for the circumferentials.

At the faces of the dam, the outlets on the supply headers were at first left open, but were closed at the first appearance of grout color. Later, when thick grout was being used, they were again opened to fill the end of the pipe, but after this was done they were closed permanently. If radial joints were being grouted, all $^1/_2$-in. risers on the downstream face were opened, and later recapped when thick grout appeared. In grouting circumferential joints, all 1-in. risers were opened at the start.

The rate of filling the joints was determined either by gages on the supply-header outlets or by the flow of grout from the $^1/_2$-in. risers at the downstream face. As soon as the latter was noticed, the gallery crew were so advised by the inspectors at the faces of the dam. Slow joints were given extra batches as conditions required, while those that filled rapidly were skipped a few times. This kept all radial joints balanced as to side thrust and brought them all to a full condition at about the same time.

In grouting radial joints the intermediate circumferentials were filled with water at a rate which insured that they would be full by the time the radial joints were full of grout and before pressure was applied to them. Although there was no concern about balance and thrust in the circumferential joints, it was convenient to get them all full at the same time.

When the top outlet headers at the faces of the dam were finally closed after all air and surplus water had escaped, it was at first attempted to change to grout having a water-cement ratio of 0.60 in the case of radials and 0.70 for circumferentials. But when it was found that the thicker grout was very sluggish and did not distribute pressure evenly, this attempt was abandoned. The valves on the long risers, or standpipes, on the return vents and headers in the gallery, were still open, or were reopened. From this point on, the signal light was disregarded. The crew tending the valves in the gallery went from joint to joint feeding grout in each until a flow was had from the top of the riser. This process was repeated until the grout stood in all risers and did not settle.

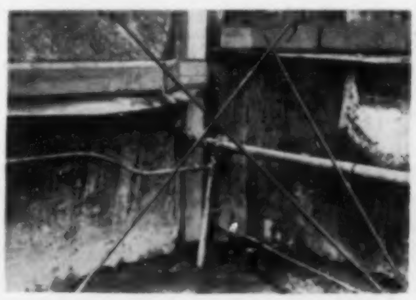
#### APPLYING PRESSURE TO GROUT IN JOINTS

With all joints full, a light trial pressure of about one-half the final pressure was first given to each joint in turn, to re-test the outlet headers for trapped air. In operating the gallery valves for this test work, a method was used which differed from that used in joint filling in that the valve at the first joint was opened and closed before the next one was opened, and in this short interval the pump was automatically stopped. The pressure regulator then functioned, preventing excessive pressures on the grout line and automatically slowing the pumping rate as higher pressures were reached.

After the trial pressures, water was turned into the lift above through the top headers. The bottom headers were partially closed so as to permit the discharge of only a very small stream. If any leaks existed they were indicated by the color of this stream. When grouting radials, the adjacent circumferentials were filled with water shortly after grouting was started and handled in the same way. Usually by this time most of the leaks had been reported. Leaks into galleries or shafts were calked or patched as rapidly as possible. A check was made of the joint openings for guidance in handling them under pressure.

From this point on, the inspector at the face of the dam on the side being grouted was advised as to what joint pressure was being applied, and when the pressure reached a predetermined limit (generally 50 lb), he notified the gallery. The line pressure in the gallery was recorded along with the pressure at the face, and the next joint was then taken. To prevent excessive pressures, the men watching gates at the joints released sufficient grout to hold the pressure to the required maximum.

After each cycle, the actions of the gages were observed. A slow drop indicated that the joint was holding pressure, while a rapid drop usually meant a leak. Dial gages across joints were again checked, and joints found to be opening rapidly were given less pressure than the others. Pressure was then applied again and the operation repeated. Joints which held pressure in a satisfactory manner were not given pressure on the next round. Those leaking to the lift above could not be expected to retain more pressure than 20 to 25 lb per sq in. Joints that failed to hold pressure satisfactorily were generally given more grout to be certain that all water had been removed, and the operation was repeated until satisfactory results were obtained.



JUNCTION OF COPPER GROUT STOPS IN CORNER OF FORM

Showing Radial (Right) and Circumferential (Left) Horizontal Seals and Vertical Seal on Circumferential Joint. The Large Pipe Is a Circumferential Return Header

After the best practicable results were obtained, the

grouting was stopped and the clean-up started. Water was cut off from joints into which no leaks had occurred, and washing of joints into which grout leaked was started. Each such joint was alternately filled and drained until the water remained clear. Radials which had been filled with water to balance grouting pressures, were allowed to remain full until the grout in the adjacent joints had set.

In grouting the two upper lifts, where joint areas were relatively small, it was found that the pump, when operated at the slowest speed, filled the joints too fast and trouble was experienced in removing entrapped air. The system was therefore changed from rotation to simultaneous grouting of all joints at one time. The area of the entire group of joints was comparable to a single one of the large joints in the lower lifts, and the method of operation was similar.

TYPICAL CONNECTIONS ON THE DOWNSTREAM FACE

A Return Header Appears at the Top, with Pressure Gage and Riser. Beneath Is a Water Line with Hose Connections. The Dial Gage for Measuring Joint Movement Is Under the Board Just Below the Water Pipe

### SOME DIFFICULTIES AND THEIR REMEDIES

In the lower lifts of the dam many of the headers were found plugged by laitance and sand resulting from cleaning the tops of the blocks and a limy deposit from the saturated curing water, which often accumulated in the joints. This did not prevent grouting of the joints, for where the bottom headers were plugged, grout was admitted through the top or return header. It was necessary under such conditions to admit the grout slowly so as not to force it entirely through the section and out at the other end.

Vertical seals at the faces of the dam gave no trouble, but many of the interior vertical seals leaked badly. The downstream wall of the two elevator shafts coincided with the circumferential joints and leaked a number of times. It was often necessary to calk many feet of joint to stop a small leak, as the seal was several inches from the face where the calking had to be done. Each of the radial joints had split tile drains near the upstream face, with seals on both sides. Several times these seals leaked and would not hold grout with a water-cement ratio of 0.50. Finally the drains were filled with fine silt to be washed out by jetting after the grouting was completed.

Several of the supply headers in the lower lifts and in upstream sections of joints at the abutments were plugged by grout which had leaked through from the lifts below. In general, the return vents were used for the admission of grout under such circumstances. This trouble was later eliminated by providing outlets into the lower galleries for the supply headers.

The sluggish action of thick grout was noticed during the grouting of the radial joints in the lift between El. 975 and 1,025. When grout having a water-cement ratio of 0.60 was used under pressure, the gages on the upstream and downstream outlet headers differed by from 25 to 40 lb. When grout having a water-cement ratio of 0.70 was used, the gages agreed closely. On account of the narrowness of the circumferential joints, the water-cement ratio was limited to 0.80 when grouting them.

Leakage of grout into ungrouted cooling pipes caused some minor trouble. During the application of pressure to grout in a joint it was sometimes noticed that the pressure was communicated to one or two adjacent ones. Grout leaked a number of times into conduits, carrying cables from thermometers and from joint and strain meters embedded in the concrete. These leaks required calking of the conduit at the first junction or pull box.

### CORE BORINGS PROVE EFFECTIVENESS OF THE WORK

After about 75 per cent of the joints had been grouted, a number were core-drilled to determine the effectiveness of the work. About 500 lin ft of drilling was done, giving a $1^{5}/_{8}$-in. core. The holes, which were selected to cover as wide a range of conditions as possible, indicated that as a whole the work was very satisfactory. The core borings revealed the following:

1. The bottoms of several of the joints were filled with sediment, sand, and laitance.
2. Some of the tops were incompletely filled or contained a chalky material, probably laitance from the grout.
3. Practically all joints showed a thin white layer between the grout and the concrete—a coating left on the concrete by the curing and wash water.
4. Double layers of grout were found in joints which had leaked during the grouting of the foundation under pressures ranging up to 900 lb.
5. Where dial gages placed across the joints at the bottom of a lift indicated a wide opening during the application of pressure, the cores were never found to be held together by the grout.
6. Joints thought to be incompletely grouted were found well filled.
7. Joints as thin as 0.01 in. were found well grouted.

In order to be certain of filling the joints, particularly where lower lifts had opened during the grouting of an upper lift, the horizontal seals might be omitted. If this were done, no pressure would be applied, but the joints would be filled slowly with thick grout. Upper lifts would be washed out to remove any grout which might have leaked into them and reduced the efficiency of the grouting system.

Where circumferential or longitudinal systems are arranged to be grouted in rows, as at Boulder Dam, two top or return headers should be used to eliminate the chance of skipping any single joint. Grout pipes should be brought into the walls of galleries rather than up through the floor, to prevent possible plugging with debris. If possible, all layouts should provide for natural drainage of the system, to eliminate as far as possible plugging between the time of installation and grouting.

Boulder Dam was built by the Six Companies, Inc., as contractors for the U. S. Bureau of Reclamation, of which the late Elwood Mead was commissioner (John C. Page, now acting). R. F. Walter is chief engineer; J. L. Savage, chief designing engineer; Walker R. Young, construction engineer; and Ralph Lowry, field engineer. The writer had responsible charge of all contraction-joint grouting. All except Mr. Lowry are Members of the Society.

# ENGINEERS' NOTEBOOK

*From everyday experience engineers gather a store of knowledge on which they depend for growth as individuals and as a profession. This department, designed to contain ingenious suggestions and practical data from engineers both young and old, should prove helpful in the solution of many troublesome problems.*

## Characteristic Points Aid in Constructing Moment Diagrams

*By* Robins Fleming
American Bridge Company, New York, N.Y.

WHAT are characteristic points? "Never heard of them," is the usual reply of structural engineers when asked the question. This is not altogether strange. The writer knows of no American textbook that treats of them and of but two or three where they are mentioned. Yet they have provided such a simple and rapid means of constructing moment diagrams for fixed-end beams and continuous beams that they deserve considerably more than passing attention. A brief presentation of the subject should therefore be of interest.

In 1883 Professor Thomas Claxton Fidler first called attention to characteristic points in a paper entitled "Continuous Girder Bridges" (*Proceedings* of the Institution of Civil Engineers London, Vol. 74). Referring to the curve of the bended girder, he wrote: "A comparison of this deflection curve with the diagram of moments from which it has been constructed shows that in every span of a continuous girder there are a certain pair of 'characteristic points' in the diagram of moments, which are so situated that the position of each point above or below the datum line indicates and measures the upward or downward slope of the girder at the adjacent pier; and with the aid of these 'characteristic points' the solution of the problem is completed."

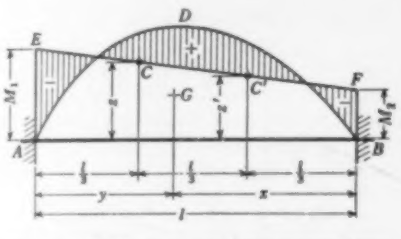



Fig. 1. Location of Characteristic Points for Fixed-End Beams

An elementary knowledge of the subject can be obtained from "The Theory and Design of Structures," by Ewart S. Andrews (fifth edition, London, 1932, pages 264–276). Figure 1 of the present discussion is taken from that book. It represents the bending moment from a given loading on a beam with restrained ends. The area of the free moment diagram $ADB$ (the moment diagram if ends were simply supported) is denoted by $s$. Its centroid $G$ is at distances $x$ and $y$ from the ends as shown. To quote from Andrews:

"Let $C$ and $C'$ be points upon the third lines at distances $z$ and $z'$ above the base $AB$, given by the relations

$$z = \frac{2sx}{l^2} \quad \ldots\ldots\ldots\ldots \quad [1]$$

$$z' = \frac{2sy}{l^2} \quad \ldots\ldots\ldots\ldots \quad [2]$$

Then the points $C$ and $C'$ are called characteristic points."

Professor Andrews shows that the closing line $EF$ passes through the points $C$ and $C'$. It is thus seen that in a fixed-end beam the characteristic points are the points of intersection of the moment closing line with the verticals through the center of gravity of the $\frac{M}{EI}$ diagrams for the two end-restraining moments.

If in Fig. 1 the total load, $W$, is uniformly distributed, the bending moment diagram is a parabola symmetrical about a vertical axis, with a height of $\frac{Wl}{8}$ and an area of $\frac{Wl^2}{12}$. The distances $x$ and $y$ are each $l/2$. Substituting these values in Eqs. 1 and 2, $z = z' = \frac{Wl}{12}$, or two-thirds the height of the free moment diagram. The closing line is parallel to the base line.

In Fig. 2 is shown the case of a single load, $W$, at any point. The free moment diagram is a triangle of height $\frac{Wab}{l}$ and area $\frac{Wab}{2}$. The distance $x$ equals $\frac{l+b}{3}$, and $y$ equals $\frac{l+a}{3}$. Substituting in Eqs. 1 and 2,

$$z = \frac{Wab(l+a)}{3\,l^2} \text{ and } z' = \frac{Wab(l+b)}{3\,l^2}.$$

If the single load is concentrated at the center, $a = b = l/2$, and $z = z' = \frac{Wl}{8}$, or one-half the height of the free moment diagram. For equal concentrated loads, $W$, at the third points, the free moment diagram is a trapezoid of height $\frac{Wl}{3}$ and area $\frac{2Wl^2}{9}$. The distances $x$ and $y$ are each $l/2$, and from Eqs. 1 and 2, $z = z' = \frac{2Wl}{9}$, or two-thirds the height of the free moment diagram.

A continuous beam of two unequal spans is shown in Fig. 3 (reproduced from Andrews). "The essential condition in a continuous beam is that the slope of the beam at any support must be the same whether calculated

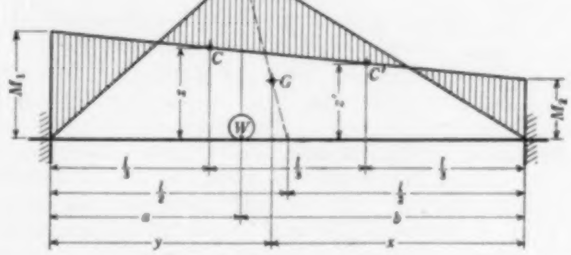



Fig. 2. Use of Characteristic Points to Construct Moment Diagram; Single Load at Any Point of Fixed-End Beam

for the end of one span or the beginning of the next." The imaginary shear is calculated at Point 2. Taking the first span, it is proved from moments about Point 1 that the area $s_1$ equals $-\frac{\overline{c_1z_1}}{2}\, l_1$ (in which the symbol $\overline{c_1z_1}$ represents the distance between the points $c_1$ and $z_1$). Taking the second span, it is proved from moments about Point 3 that $s_1$ is also equal to $\frac{\overline{c_2v_2}}{2}\, l_2$.

"Since these imaginary shears represent slopes of the beam at the Point 2 considered from the two spans, and they must be the same, we have

$$-\overline{c_1z_1}(l_1) = \overline{c_2v_2}(l_2)$$

"This shows that the characteristic points on opposite sides of any support must be, respectively, above and below the reverse bending moment base lines *cd* and *de* and that the distances above and below are inversely proportional to the spans." Andrews makes this division by trial. Salmon illustrates a "pin-and-string method" which he thinks for a large number of spans is probably the quickest and best method of determining the base line. Professor Ostenfeld of Copenhagen has devised a graphic method.

For those interested in pursuing the subject further, the following additional references will be of value.

No. 46 of "Selected Engineering Papers," the Institution of Civil Engineers (London), published in 1927, is a 37-page monograph, "Characteristic Points," by Ernest Hinkly Salmon. Dr. Salmon shows in detail how the ordinates to these points are derived, and gives the method a far wider application than suggested by Professor Fidler. The case in which the moment of inertia is different in adjoining spans, and the case in which it is different at all points in the same span are considered. Special problems, as bending moments for stiffeners in a partly filled water tank, and loaded brackets on a column, are taken up.

Three contributors to the discussion of the paper of

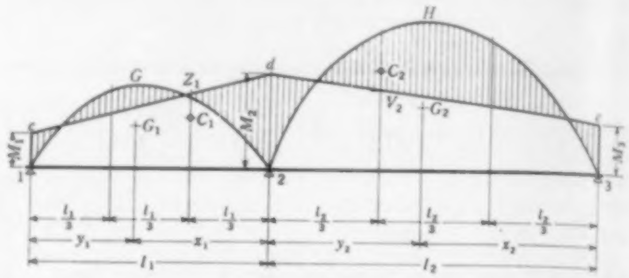


FIG. 3. LOCATION OF CHARACTERISTIC POINTS FOR A CONTINUOUS BEAM OF TWO SPANS

L. H. Nishkian and D. B. Steinman, Members Am. Soc. C.E., on "Moments in Restrained and Continuous Beams by the Method of Conjugate Points," (*Transactions* Am. Soc. C.E., Vol. 90, 1927, pages 1–206) give decisive testimony to the usefulness of Fidler's method of characteristic points. They are F. E. Richart and S. M. Cotten, Members Am. Soc. C.E., and Walter Ruppel, Assoc. M. Am. Soc. C.E. Mr. Ruppel, in addition to his exposition of the Fidler method, supplies 26 tables that are invaluable in the solution of problems involving haunched beams.

An article by Mr. Richart and W. M. Wilson, M. Am. Soc. C.E., entitled "Graphical and Mechanical Analysis of Frames" (*Engineering and Contracting*, June 23, 1920), and a staff article entitled "Structural Design Problems" (*The American Architect*, May 10, 1922) might also be consulted.

# New Design for Brewery Stock Houses

*By* MILO E. SMITH

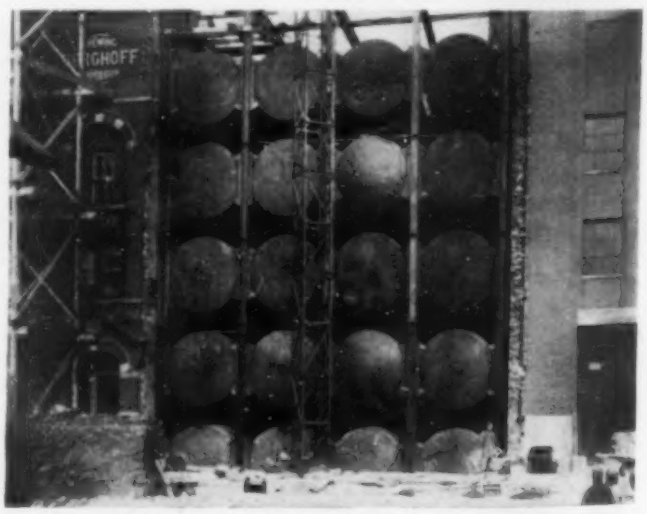
CHICAGO BRIDGE AND IRON COMPANY, CHICAGO, ILL.

THE ordinary method of providing storage capacity for beer has been to build a stock house or cellar with regular floors and to place storage tanks of various sizes and construction on these floors. In recent years many of these tanks have been constructed of steel. Some of them are mounted in a horizontal position and others are set vertically.

Recently we have made several installations in which an entirely different method of construction was used. These installations are limited to locations where new stock houses are constructed, as an old building with existing floors cannot be utilized.

The cylindrical tanks are fabricated in uniform sizes in the shop. To each end of each tank are welded two wing plates, designed to fit into the structural framework in such a manner that the tanks themselves provide the lateral bracing for the building. Tanks and framework are installed simultaneously. As the tanks are supported entirely on the framework at the ends, there need be no floors between them. A runway is usually placed along one end of the battery, or between the batteries if the tanks are arranged in two groups. After the steel erection is completed, the building is bricked in and roofed. The inside of the building is lined with cork insulation.

In addition to permitting a considerable saving in material, this design makes for economy in operation as well, for the floorless construction enables the entire stock house to be cooled uniformly with one set of coils arranged at the top. The air has free circulation throughout the building, and the extreme range in temperature throughout a big installation is no more than 2 F.



A BREWERY STOCK HOUSE OF NOVEL DESIGN

No Floors Are Required, and the Tanks Themselves Provide the Lateral Bracing

# OUR READERS SAY—

*In Comment on Papers, Society Affairs, and Related Professional Interests*

## Reinforced Concrete Design

To the Editor: I should like to comment briefly on the subject of designing reinforced concrete structures. There is no doubt that the amount of steel to be used is one of the most important factors in the design of such structures. The size of bars and, of course, their spacing and proper location in the footing, column, beam, or slab are also fundamental considerations. I have found that, in this tropical region, better designs are obtained by using bars of small section and of course the proper number to get the total area of the steel section required, than by using large bars.

Experience has shown me that vibrations are transmitted with less intensity and thus less possible damage, if the bars are small. I have examined several structures, especially railroad bridges, and I have noticed that in many places where large rails or bars have been used as reinforcement there are marks and cracks in the surface under which the rails and bars were placed, although they were placed at least 2 in. from the surface. In structures where smaller bars were used, the surface appears clean and without cracks.

After the Puerto Rico earthquake of October 1918, I examined many reinforced concrete structures, especially buildings and bridges, and I noticed that columns, beams, and slabs reinforced with small bars had fewer cracks than those in which larger bars had been used. The destruction appeared to affect the whole structure where the larger bars were used, while the radius of destruction was smaller when the bars were smaller. The larger, stiffer bars transmit the vibrations through the structure, while the flexible, or small, bars transmit to the adjacent concrete with less intensity any violent shock or movement that the structure may receive in earthquakes or cyclones. It may be said that the adjacent concrete absorbs the shock.

In case of fire, the larger bars will transmit the heat through the structure more quickly, as metals are among the best conductors of heat. Since the small bars carry less heat, the average temperature is obtained more quickly with them than with the large bars, as the concrete around the bar absorbs the heat.

Besides these considerations the subject of adhesion or bond is one of the main factors to be considered in the design of reinforced concrete structures. The smaller the bars the larger the surface area, relatively, as the perimeter, compared with the area of the section of the bars, is relatively larger in small bars than in large ones. It must be remembered that bars of smaller section are more easily bent and that it is easier to place them properly in any structure. They can be placed nearer the surface than large bars and closer together. Also the larger the number of bars used, the greater the coefficient of safety, as in case of failure all the bars would not give at the same time. We engineers must always remember that our worse enemies are cyclones, earthquakes, fires, rains, and sudden changes of temperature.

Etienne Totti, M. Am. Soc. C.E.
*Chief Engineer, Maintenance of Ways and Structures, American Railroad Company of Puerto Rico*

*San Juan, Puerto Rico*
*December 23, 1936*

## Filing Technical Literature

To the Editor: The article by E. W. Lane, M. Am. Soc. C.E., in the December issue, is the best one that has come to my attention on the filing of technical literature, particularly clippings. No system can be ideal for all engineers, and an engineer starting a file would, no doubt, make a better selection of a system for his own use if he knew of the experience of others. To help in such a selection I will explain where my system differs from Mr. Lane's.

Experience with a classification of personal selection, with a classification published in 1916 as Appendix B of *Twenty-Five Years of Society Activities* by the late Charles Warren Hunt, M. Am. Soc. C.E., and with the Dewey Decimal System (which I have used for fifteen years), shows the advantages of the last, with its continual improvement and universal use. Unlimited expansions of small parts of the Dewey classification can be made with less work than is required in devising one's own classification. Later expansions, when too many clippings accumulate under one number, are easily made. It is also convenient for filing the occasional clippings on subjects of interest foreign to one's specialty. The standard text on this system is *Decimal Classification* by Melvil Dewey, which is now published by the H. W. Wolf Company, 950–972 University Avenue, New York City.

Mr. Lane's sensible suggestion that whole sheets only be used in filing clippings also has the advantage of preserving the name of the publication and the date without additional effort. Several sheets can be held together by folding once to form a 6 by 9-in. sheet. This will eliminate the necessity of using staples, which are somewhat objectionable in the file when used to hold only a few pages. Most clippings consist of only a few sheets and will keep in better condition folded, in a special vertical file for 6 by 9-in. sheets, than will the full magazine page in a standard letter file.

A special six-drawer vertical file case for 6 by 9-in. sheets is narrower than the standard four-drawer letter file but of the same height and depth, and because of its smaller drawers it is more convenient to use. For limited amounts of filing, a box of suitable size will take the place of the more elaborate file case, but it should have the standard guide rod at the bottom. Marked guides are not of value as the continual change makes the marking inappropriate. Unmarked guides threaded on the bottom rod should be provided at intervals of not more than two inches to hold the files vertical and in good order without the use of folders.

Cross-references can be made by placing one or more additional file numbers at the side of the clipping away from the regular number to cover the subordinate subject. A cross-reference sheet, with the subordinate number as its main number and a reference to the main number of the clipping, is filed under the proper head for the subordinate subject.

Many pamphlets are 6 by 9 in. in size and are more conveniently filed in a case of this size than on a shelf. Although it is difficult to file smaller pamphlets satisfactorily, they can be pasted to a piece of cardboard that will fit the file. Larger sizes up to 9 by 12 in. are filed under the same classification and in a standard letter file.

Gage Haselton, Assoc. M. Am. Soc. C.E.

*Portland, Ore.*
*January 5, 1937*

## Details on Castelmoron Bridge and Gotha Canal

To the Editor: In the December issue, David C. Williams points out that Freyssinet was not the designer of the Castelmoron Bridge, but that it "was entirely designed and constructed by the French firm, Établissements Christiani and Nielsen." Permit me to point out that Christiani and Nielsen is a Danish engineering firm with far-flung activities. Among their many subsidiary (in Danish called "daughter") companies is also the one in Paris, mentioned by Mr. Williams. The plural form of "Établissments" conforms to the fact I have stated.

In the same issue I was interested in the article on "Constructing the Caledonian Canal," by John F. Baker, Assoc. M. Am. Soc. C.E., and John Armitage. Under the head, "Building the Gotha Canal," Professor Baker states, "The work, following his [Telford's] plan, was started in 1810. The total length of waterway was 120 miles, 55 of which were through existing canals." As there was no existing canal east of Lake Vaner, then, I do not know what the author had in mind. It happens that 55 miles is the aggregate total length of artificial waterway on the entire canal (west and east section), which has a total length of 240 miles.

R. Reimann, M. Am. Soc. C.E.

*Baltimore, Md.*
*December 17, 1936*

## Pump Maintenance at Fort Peck

To the Editor: The article on "Placing Hydraulic Fill at Fort Peck," by T. B. Larkin, M. Am. Soc. C.E., in the October issue, is of considerable interest. The successful execution of the task of placing 100,000,000 cu yd of hydraulic fill depended largely upon four vital factors: (1) proper organization, (2) adequate design of dredging plant, (3) efficient operation, and (4) thorough and prompt maintenance. The first three factors will be discussed briefly and the question of maintenance, in more detail.

The problem of organization was very difficult at Fort Peck, and the work of assembling personnel for the dredging operations was started a year in advance of the actual need for specialized labor. Although most items of heavy construction equipment have been standardized and can be purchased from stock to fill particular needs, no dredge had ever before pumped against the lift required, nor had the operation of five dredge pumps in series been employed. The operation of dredging units of the size of those at Fort Peck, using five 2,500-hp pumps in series, involved so many variables that no fixed rule could be laid down for determining the best pressures, pump speeds, and combinations of distances between pumping elements for maximum production. In consequence, the combination of speeds, pressures, and distances that will place the maximum yards per hour in the fill is determined for each set-up by the trial-and-error method.

Table I. Data on Pump Parts Particularly Subject to Wear

| Reference No. | Part | Composition | Condition After 2 Months' Use | Economical Life |
|---|---|---|---|---|
| 1 | Manhole casting ring liner | Nickel-chrome steel | Worn out; points on casting abraded | 3 weeks |
| | Impeller ring liners | Nickel-chrome steel | Medium wear | |
| 2 | Front head liner | Cast steel (ASTM A27-24) | Badly worn along periphery | 6 weeks |
| 3 | Back liner | Nickel-chrome steel | Worn through to quarter liner, with maximum wear on outer half | 6 weeks |
| | Quarter liner | Nickel-chrome steel | | |
| 4 | Periphery of impeller | Cast steel (ASTM A27-24) | Worn most severely on outer portion of vanes and sides | 6 weeks |
| 5 | Shoulders of pump shell | Cast steel (ASTM A27-24) | Severely worn, exposing studs at some points | 3–4 weeks |

Maintenance of the dredging equipment means principally the maintenance of the 28-in. centrifugal pumps. Twenty pumps are kept in operation at all times, while an equal number are being repaired. By improved methods and careful planning, the average time of 15 hours formerly required to make a complete change of pumps for one unit has been cut to an average of 8 hours.

The first dredge started operation in October 1934 and pumped 800,000 yd in about two months. At the end of this period the pumps were dismantled and conditions noted, as shown in Table I. The numbers on this table refer to parts in Fig. 1.

This inspection led to the conclusion that the critical part of the pump assembly would be the shoulders of the shell. During the 1935 dredging season, complete pump changes were made on an average of once in three weeks. Experiments to increase the length of time necessary between pump changes—that is, to lengthen the life of the shell shoulders—have been continued. With the use of applicator bars made of special abrasive-resisting alloys and plug welded to the casting, it is expected that this part will have a useful life of eight weeks. In this case it will be desirable to increase the life of the other parts to eight weeks. The applicator bars have been tried with promise of success, and refinements of this method are now in operation or soon will be. Proposed changes, shown on Fig. 2, are as follows:

1. The manhole casting ring liner and impeller ring liner are to be of rubber vulcanized on to steel backing plates. These rings are to be in one piece.
2. The front head liner is to be of nickel-chrome cast-iron.
3. The back liner is to be made in two concentric rings, the inner ring of nickel-chrome steel and the outer ring made integral with the quarter liner of nickel-chrome cast-iron.
4. The impeller will be of manganese steel.
5. In forming the pump shoulders, the first method consisted of the use of nickel-manganese steel bars on both the periphery and the sides of the shoulders. For the second method, it was planned to use rubber molded around steel stiffeners in eight sections for the periphery, and nickel manganese steel bars for the sides of the shoulders. Finally, rubber vulcanized on steel angles was used to form the shoulders (Fig. 2).

In addition, as shown on Fig. 2, rubber seal rings will be used in conjunction with the front and back head liners, and rubber backed with steel for impeller mouth liners.

Clark Kittrell, M. Am. Soc. C.E.
*Major, Corps of Engineers, U.S. Army; Acting District Engineer, Fort Peck District*

*Fort Peck, Mont.*
*December 29, 1936*

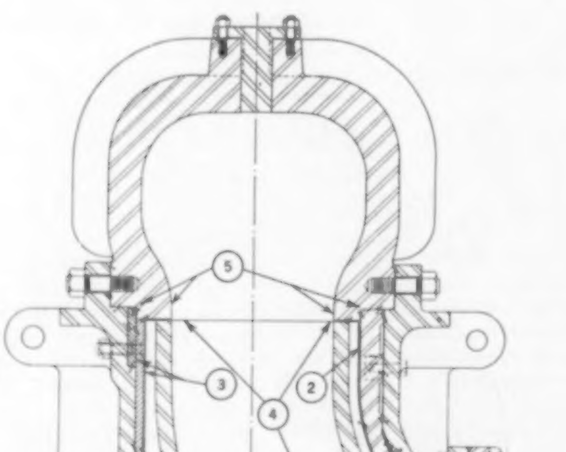



Fig. 1. Section Through Pump Showing Original Case and Liners and Points of Greatest Wear

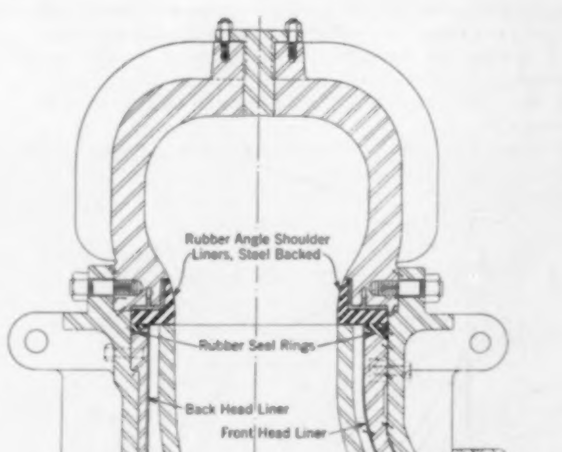



Fig. 2. Section Through Pump Showing Rubber Angle Shoulder Liners, Steel Backed, with Rubber Seal Rings

## Social Versus Economic Considerations in Engineering

DEAR SIR: The article by J. K. Finch, M. Am. Soc. C.E., on "The Social Responsibilities of the Engineer," in the December issue, must indeed strike a responsive note in the hearts of American engineers. Professor Finch's response to the request for a greater understanding of the social responsibility of the engineer is clear, sound, and to the point.

That the separate and distinct social and economic aspects of the public-works projects are deserving of study, consideration, and a generous understanding is apparent. However, the inference that both professional engineers and those being trained in our engineering institutions are fundamentally lacking in the vision required to comprehend the generous objectives outlined by those in whose hands the leadership of our country rests, is a grievous misconception.

It is a common experience that on any public work that requires the expenditure of public funds and is based on the essential knowledge and experience of the engineer, the lot of the engineer is generally to "play in the line." At best, he generally receives only the rôle of "blocking back" while someone else "carries the ball" to the acclaim of the man on the street.

This analogy will be apparent to Professor Finch's students. Theirs is the chosen lot of Kipling's "Sons of Martha" reprinted in the March 1936 issue of CIVIL ENGINEERING. Their acclaim will consist largely of the knowledge of a job well done; and it will take additional hardiness of constitution to withstand the blame or attempt to furnish the justification if or when those "carrying the ball" fumble it.

Professor Finch refers to the fortunate circumstance of the discontinuance of great but economically unsound projects when "common sense put an end to them." Such common sense or, as some incisive individual very aptly put it, "uncommon sense" is a characteristic of engineers, and it must be cultivated in the engineers of the future not as a handicap to their vision or their sense of social responsibility, but as a foundation for those desirable qualities as well for their specific economic and engineering training.

Perhaps it remains for the engineer to devise some scale of evaluation for the social aspects of many public projects, and it appears that if no one else will undertake the task, he will have to do so. If he does make such an evaluation, it will be based upon the soundest principles, with limitations fully defined and qualified, and not upon uncontrolled optimism.

For the present, the suggestion that engineers should confine themselves chiefly to their own field would appear to be the best advice. This will not deter them from enlarging their scope in the field of social aspects connected with their work. However, it might be suggested that individuals particularly concerned with social aspects enlarge in turn their understanding of the economic aspects of any joint program for common welfare involving public works or construction.

There can and must be a happy meeting of thought in this regard if the great public-works programs under way and in prospect are to be successful both socially and economically. Let the proper weight be given to the technical and definable aspects of a job, and engineers will not be found wanting in a reasonable appraisal of the so-called intangible values.

ERIC FLEMING, M. Am. Soc. C.E.
*Civil Engineer, National Park Service*
*U. S. Department of the Interior*

*Washington, D.C.*
*December 30, 1936*

## More About Selecting Names for Dams

DEAR SIR: Now and then I note a discussion in CIVIL ENGINEERING on the subject of the correct name for Boulder Dam. Why not resolve the question into its constituent parts? The dam is located at the upper end of Black Canyon. Therefore, why not call it Black Canyon Dam if a correct territorial name is desired? Boulder has nothing to do with the case. It would be as logical to call a dam for a laundry in Troy, N.Y., the Catskill Dam. Before the dam was built a trip upstream from Black Canyon to Boulder would, according to the doctrine of relativity, be about equal or equivalent to a trip to the moon.

Dams or other expenditures of O. P. M. (Other Peoples' Money) are the result of several types of individual action. The dreamer, the promoter, the surveyor, the designer, and the executor—all have an important part. Among these President Hoover occupied a very prominent place. He did as much as, or perhaps due to his official position, more than any other. Since he was an engineer, engineers should see that he gets the glory, even if politics is vastly concerned in the matter.

As a matter of logic, dams should be numbered in sequence from headwater down—No. 1, No. 2, and so on. It would clarify the situation for anyone desiring to know the real problem involved. But this practice has not been followed in the West. The Muscle Shoals dam is called Wilson Dam. Somebody hoped that the President would row upstream sometime when fishing. Another dam is known as Norris Dam. Who in Tennessee is called Norris? Nobody knows. If local names are to be used, why not have them refer to construction difficulties?

The dams on Salt River should be changed—Roosevelt to Salt River No. 1 and the others in sequence. Coolidge Dam should be San Carlos or Apache No. 1, and so on. The most logical name for the so-called Boulder Dam would be the Hopi.

If names are to be changed at any time, why not change the name of Elephant Butte. The elephant connotes G. O. P. Call it "Donkey Dam." Burros are plentiful thereabouts.

This reminds me of a game of golf I played with an English bishop. When not satisfied he raised his arms in an ecclesiastical gesture and shouted, "Assuan! Assuan!" At the nineteenth hole I asked his lordship its significance. He replied, "Don't you know? It is the biggest dam in history."

PAUL M. LA BACH, M. Am. Soc. C.E.
*Consulting Engineer*

*Los Angeles, Calif.*
*December 31, 1936*

## Facts About Engineering Survey in California

DEAR SIR: Of passing interest to some who chanced to peruse the figures submitted in the item on "The Education of the Engineer," in the August issue of CIVIL ENGINEERING, may be the fact that, whereas the total replies from professional engineers of all classes in California to the inquiries of the Bureau of Statistics of the federal government numbered 4,389, the number of civil engineers registered under the Civil Engineers Registration Law of California, as of July 25, 1935, was 4,346. On the basis of this latter estimate, one might reasonably infer that there are upwards of 10,000 professional engineers of all classes in California.

Now, of course, there are not 10,000 engineers, nor 4,389 civil engineers, engaged in responsible professional practice in California. The explanation of the registration figure lies in the fact that, despite the intent of the law, as evidenced by its history, to limit its application to the practice of civil engineering as distinguished from mining, mechanical, electrical, chemical engineering, etc., the Board of Registration chose to revert substantially to the generic definition of civil engineering, as including all engineering that is not military, and to advise engineers of all kinds, and persons and concerns having generally to do with the mechanics, machinery, or materials of construction, accordingly. All such persons willing to pay the registration fee were grouped under the law and may, during lawful behavior, call themselves, and be recognized legally as, civil engineers.

E. T. THURSTON, M. Am. Soc. C.E.
*Consulting Engineer*

*San Francisco, Calif.*
*December 16, 1936*

# SOCIETY AFFAIRS

*Official and Semi-Official*

## Louis C. Hill, President for the Year 1937

How FAR and how fast a man can travel toward the peak of his profession, providing he has innate ability and keeps the goal always in view, is aptly illustrated by the experience of Louis Clarence Hill. He began with the inspiration and ambition to succeed as a civil engineer and he now finds himself, after a lifetime of persistent effort, fine character, and professional idealism, honored by his fellows with the most enviable office in his chosen field.

LOUIS CLARENCE HILL
President American Society of Civil Engineers

His inspiration came early from the example of an uncle who was employed in the U. S. Engineer Department on the upper Mississippi River. Impelled by a form of hero worship, young Louis Hill decided that he too would make his place in the engineering world. And he proceeded to put his resolution into effect, entering the University of Michigan in the class of 1886 and receiving a civil engineering degree. This class was one of the first graduated under Dean Mortimer E. Cooley, Hon. M. Am. Soc. C.E., who had accepted a chair in engineering a few years previously.

A period of employment on railroad location immediately followed, first as instrumentman on location in northern Minnesota and Dakota during the winter of 1886–1887. This was no easy task when the thermometer fell as low as 50 degrees below zero and tents were the only protection against the weather. He recalls how this experience cured him of smoking. It seems that the chief of party was addicted to smoking a cheap tobacco in a huge pipe as he pored over his notes at the end of the day. The tent became filled to suffocation with a blue fog of smoke, and although the rest of the party could hardly endure the ordeal, no one dared to open the tent and clear the atmosphere. And, anyhow, it was too cold for ventilation.

This experience does not seem to have handicapped his advancement, for he was soon transferred to construction on the same railroad as division engineer. However, he had left a young lady behind him in Ann Arbor and the life of a railroad engineer in the muskegs of Minnesota had few attractions for a man with a desire to get married and settle down.

So in 1888 we find him back in Ann Arbor, this time pursuing a course in electrical engineering, then in its infancy, at the University of Michigan.

Two years later, the young civil engineer had completed his new course of study and was entitled to the additional degree of bachelor of science in electrical engineering. With his second diploma won, he was ready to fulfill his greatest ambition—he and Gertrude B. Rose were married in Ann Arbor the following August. She had graduated from the University only the previous year, but there were other bonds of common interest—the mothers of both had been girlhood chums, born and reared together in Ann Arbor. With such an auspicious beginning, it is no wonder that the marriage was, and has continued to be, a most happy one.

During his second period at the University, Louis Hill conducted some of the first research into the most desirable shape and form of what is now known as the Pelton and Doble type of impulse water-wheel bucket. These studies established his interest in hydraulics, which has continued undiminished throughout his career.

Immediately Mr. Hill's services were sought by the Colorado School of Mines at Golden, and he accepted the position of professor of hydraulic and electrical engineering. The sequel proved the wisdom of his choice. He was enabled to develop the home life he so eagerly sought, and the location proved so satisfactory that he remained in Golden for 13 years. It was here that the two Hill children, Raymond Alva and Margaret, were born. Rapidly his outstanding abilities were recognized, so that for the last few years he was acting president of the School of Mines and lived in the president's house, provided for that purpose.

During this period, strange as it may seem to those who have only known him in later years, Mr. Hill boasted a full head of hair and a russet Vandyke beard. In the community he was known as "Professor Hill" and even today he is so greeted by his students of 40 years ago.

But like so many ideal and comfortable situations in life, the professorship was due to be rudely interrupted. In 1903 a political upheaval in Colorado so disturbed the equanimity of the State Mining College that nearly the whole faculty resigned as a body in protest. With them went Professor Hill.

Fortunately for him as well as for the government service, the Reclamation Act, which had been passed the previous year, was just making available desirable engineering positions. The Act had created the U. S. Reclamation Service as a subdivision of the Geological Survey, of which Arthur P. Davis, later a President of the Society, subsequently became chief engineer. Thus the Service was intended to provide the vehicle for carrying out the construction of work under the Geological Survey. Professor Hill saw here an opening for exercising his talents in hydraulics, and he therefore welcomed the opportunity of entering the Service as an engineer to investigate a series of storage and irrigation projects on the western slope of the Rockies in Yampa River Basin, northwest Colorado. This work occupied the party until snow flew. In

those days the engineers of the staff wore a distinctive uniform, of khaki cloth with brass buttons carrying the seal of the U. S. Geological Survey.

About that time—it was in the fall of 1903—Mr. Hill was transferred to Roosevelt, Ariz., to build the intake dam on the Salt River and a canal for the power house at the site where Roosevelt Dam was later to be built. The old town of Roosevelt has long since disappeared under Roosevelt Lake. On this canal were built some of the first reinforced concrete pressure siphons; the one across Pinto Creek has a 6-ft diameter and works under a head of almost 100 ft.

In 1906, during the construction of Roosevelt Dam, Mr. Hill was made supervising engineer of the southern district, which included the Rio Grande and the Colorado River basin. Subsequently he completed by force account the Laguna Dam on the Colorado River and the Strawberry project near Provo, Utah; he also started construction of the Elephant Butte Dam on the Rio Grande. In this period also, during the absence of Mr. Davis, Mr. Hill acted as chief engineer of the Reclamation Service.

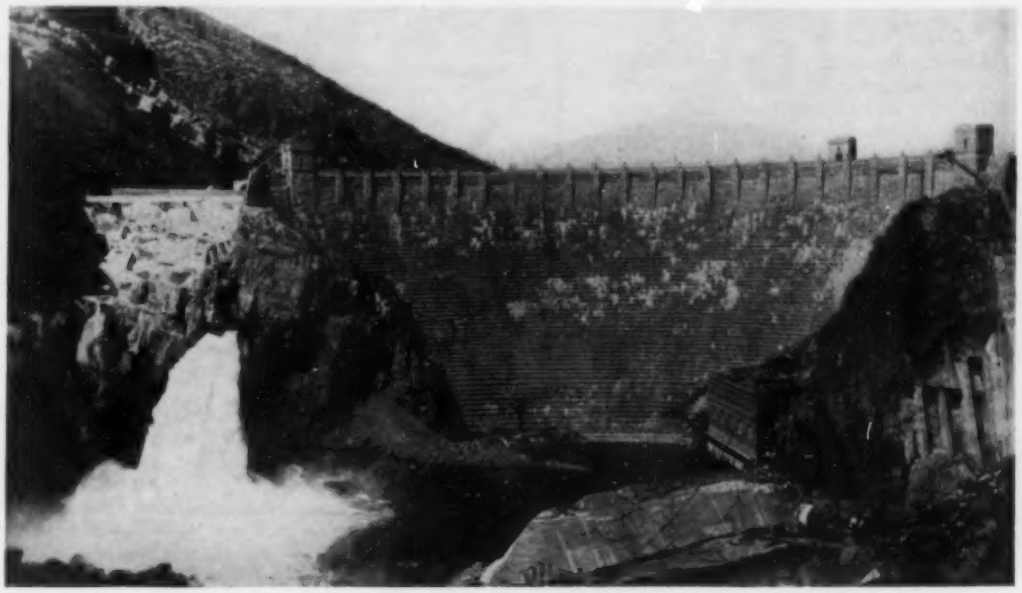
As every engineer knows, the building of Roosevelt Dam was most remarkable—in fact unique, considering the time and the surroundings. Located in a very rugged country, work on the dam was of necessity preceded by construction of a road from Mesa 60 miles away. It followed the almost impassable Apache Trail, for which it has since been named. On this road the still famous Fish Creek Hill, with its three miles of 10 per cent grade, has a rock cut of 150 ft, made by Indian labor without power equipment or air drills.

Several hundred Apaches on this job not only respected but liked their red-bearded white chief. He still corresponds with Henry Chilchinhuana, who was a young sub-chief on that work and a graduate of Carlisle Indian School. It was in the Tonto Basin now occupied by the reservoir that the Tewksbury feud of Zane Grey's *To the Last Man* was still being fought at that time.

Lumber could only be obtained from a sawmill built for this special purpose in the Sierra Ancha 40 miles away in the opposite direction. Even worse were the conditions for obtaining cement. The cost of hauling freight from Mesa, using 20-mule and longer jerk line teams, was as high as $10 a ton, and was prohibitive. The road was so crooked that the driver often lost sight of his lead mule team and, in the other direction, of the third wagon of his string, which carried the hay and grain for the mules. Ten miles was considered a fair day's travel with this kind of an outfit. It was decided to build for the government a cement plant at the dam which would utilize materials obtained locally, and would be fired with oil hauled from Globe, 40 miles to the southeast. The contractor on this dam, by the way, was John F. O'Rourke, M. Am. Soc. C.E., who later became prominent in heavy construction work around New York City.

As an indication of the vigor of the man who directed this work, it was necessary frequently for Mr. Hill to make the 60-mile trip from the warehouse headquarters in Mesa to the site of the dam in one day. It began with a 20-mile drive to Goldfield behind a team of mules hitched to a buckboard. Here the Apache Trail began, used by the Indians for years. It was indicated on the ground by but little more than smooth places worn in the rock of that unbelievably rough country by the feet of Indians and their ponies for generations. It was impassable to vehicular traffic. Mounting his horse at Goldfield, Mr. Hill would proceed to the site of the work, and would complete the 40 miles of the Apache Trail to Livingston in the Tonto Basin by nightfall.

After 7 years the construction was finished, and in March 1911 President Theodore Roosevelt dedicated the structure. After his dedication speech, in which he praised the work done and those who had accomplished it, he stopped before a group of engineers on the dam and observed, "Gentlemen, I regret to predict that your reward will be a congressional investigation." True enough, with a change in administration, politics entered in, and out of the subsequent investigation the reorganization of the Reclamation Service resulted.



Roosevelt Dam on the Salt River, Ariz.
One of President Hill's Early Construction Projects

Since the reorganization was not to his liking, Mr. Hill resigned from the Service in 1914 to set up practice in Los Angeles. At the same time he was named a consulting engineer for the Service, a connection he has maintained to this day, and which has included Boulder and many other important projects. To recount the engineering work of Quinton, Code and Hill, to which was later added the firm of Leeds and Barnard, would be to repeat what is common knowledge among American engineers. These companies have conducted one of the widest and most highly regarded consulting practices in the country. Most of the large projects in hydraulics, reclamation, and construction, not only in the West but elsewhere in the country, have called for plans and for consulting services. At one time, 18 dams were the subject of work or study by the firm. In fact it may be safely stated that hardly any important work in their field was carried on without some form of reference to them or assistance from them. Many municipalities sought their advice. In late years a number of the largest projects under the U. S. Engineer Corps, such as the gigantic dams at Fort Peck and Bonneville, have retained the consulting services of Mr. Hill.

For Mr. Hill the main interests in life have been his work and his family. He has no hobbies, unless a workshop in his Hollywood home may be so characterized. The early cure for smoking he was obliged to take, was effective and permanent. He has not fallen for golf—not very hard, at least. He admits to being the world's worst investor. Like the postman who took his recreation by embarking on extended walking tours, Mr. Hill best enjoys a vacation which permits him to travel somewhere and then somewhere else.

Although he may appear to be somewhat shy, at heart he loves the fellowship of people. And it is among engineers that he finds many of his best friends. A cognomen of his early days still pursues him, and among his older cronies the favorite question is, "What is Uncle Louis doing now?"

Such is the type of man selected as the sixty-eighth President of the Society. That he has long been so well known and is still admired and loved, is a guarantee that he has the qualities of mind and heart that his new honors demand. Leadership of the Society during the promising days of 1937 is safe in the hands of a man like Louis C. Hill.

# Features of the Eighty-Fourth Annual Meeting

WINTER'S first snow failed to chill the enthusiasm at the opening session of the Eighty-Fourth Annual Meeting, Wednesday morning, January 20. The main auditorium of the Engineering Societies Building was well filled when President Mead stepped to the platform, and downstairs the lobby was still crowded with late arrivals.

With routine matters of business disposed of, the conferring of awards began. The Secretary took the chair temporarily to present the Norman Medal to President Mead. Wilbur M. Wilson, M. Am. Soc. C.E., was next introduced as winner of the J. James R. Croes Medal, and A. V. Karpov and R. L. Templin, Members Am. Soc. C.E., jointly received the Thomas Fitch Rowland Prize. Paul Baumann, M. Am. Soc. C.E., and Clinton Morse, Assoc. M. Am. Soc. C.E., recipients respectively of the James Laurie Prize and the Collingwood Prize for Juniors, were unable to attend.

This year honorary membership was conferred upon five Members, all of whom were present to receive their certificates: Alex Dow, of Detroit; G. H. Duggan, of Montreal; Robert Hoffmann, of Cleveland; J. B. Lippincott, of Los Angeles; and J. A. L. Waddell, of New York.

Of exceptional interest was the presentation of the John Fritz Medal to Arthur N. Talbot, Past-President of the Society. This award, for notable scientific or industrial achievement, is administered jointly by the four Founder Societies and is considered the greatest honor that it is in their power to confer. Past-President Alonzo J. Hammond introduced Dr. Talbot and read the citation. Harry P. Charlesworth, past-president of the American Institute of Electrical Engineers, then made the presentation of the award.

The morning session closed with the introduction of the incoming members of the Board and the new President, Louis C. Hill.

General interest in the question of water resources control was evidenced by the unusually large attendance at the session on Wednesday afternoon. Abel Wolman opened the program with a résumé of the as yet unpublished report of the Water Resources Committee of the National Resources Committee. His paper was followed by four formal discussions, and then the meeting was thrown open to general informal discussion, which proved to be spirited and extensive.

A formal dinner and dance at the Hotel Roosevelt concluded the first day's activities. It was attended by almost 500 persons—a record crowd for recent years. A reception to the President, the Honorary Members, and the John Fritz medalist was an outstanding feature.

On Thursday, sessions were held by five of the Technical Divisions. The Power Division's session featured an open discussion of proposals for future activities. Highway engineers heard papers on state-wide planning surveys, the influence of highway improvements on traffic accidents, and the Henry Hudson Parkway. The Sanitary Engineering group convened both morning and afternoon for a varied program on water supply and sewage treatment problems. The City Planning Division discussed rural zoning and urban rezoning. The program for structural engineers included papers on steel-pile piers and motion pictures of the San Francisco–Oakland Bay Bridge.

On Thursday evening, the annual smoker took place in the ballroom of the Manhattan Opera House. The informality of the occasion, and the supply of refreshments and "smokes" engendered a spirit of sociability that put newcomers at ease quickly and encouraged them to get acquainted with their table

## In This Issue . . .



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companions. There was a brief program of entertainment, and an orchestra that furnished support for considerable informal singing.

Entertainment for the ladies on Thursday included a fashion show and tea, in the afternoon, and a theater party at night.

Friday's inspection trip was somewhat out of the ordinary. By special buses, members and their guests were taken on an all-day tour of New York, visiting such recent projects as the Triborough Bridge and Grand Central Parkway, the Henry Hudson Bridge and Parkway, the Wards Island Sewage Disposal Plant, and the West Side Park and railroad improvements.

On Saturday the meeting was brought to a close with a number of shorter inspection trips, which included the American Museum of National History, the New York Museum of Science and Industry, the Williamsburg Housing Project, Hell Gate Power Station, and the Port Authority Commerce Building.

The story of the Annual Meeting would be incomplete without a mention of the Student Chapter Conference, held on Wednesday afternoon under the auspices of the Metropolitan Student Chapters. With a student in the chair, and student speakers contributing the major part of the program, this event drew an attendance of well over 200, including many members of the Society who broke away from their own meetings "to see how the college men run things."

Mention should also be made of the luncheons and dinners, large and small, given by many groups on Thursday and Friday. In all, 16 colleges and one engineering fraternity sponsored such events.

## Determining Engineering Fee

Frequent inquiries received from members in regard to various matters that are bothering them at the moment are handled by the Headquarters staff in different ways—sometimes by reference to the Engineering Societies Library or the Society's publications, and sometimes by suggesting the name of a member known to be particularly skilled in the matter in question. On matters, more particularly those of a non-technical nature, which fall within the functions of the Society's various professional committees, the inquiry is referred to the chairman of the proper committee for reply, which may be advisory in character or may be quoted as authoritative.

An example of the latter type of inquiry, together with the reply, in this case more advisory than authoritative, is included here because of its similarity to questions many members must decide in the course of their professional work. The question follows:

"Will you kindly inform me what the base fee would be, computed in accordance with the 'Recommendations for Determining Fees to Be Allowed for Professional Engineering Services on Federal and Federal Aid Projects,' on a small water filtration plant where the construction cost amounts to $200,000?"

This inquiry was referred to E. R. Needles, chairman of the Society's Committee on Fees, who advised the following reply:

"As proposed in 'Recommendations,' the base fee to be paid for plans, specifications, etc., but without field supervision, would be 5.75 per cent for a Curve B project and 8.00 per cent for a Curve A project.

"It appears that the questioner must be concerned mainly about the use of Curve B or Curve A. It is not possible for me to discuss this subject intelligently without greater knowledge of the facts. Ordinarily, we would expect the distinction between Curve B and Curve A projects to be agreed upon by the engineer and his client. If the design of a considerable amount of mechanical equipment should be required, together with the showing of an excessive amount of detail, it would appear that this should be classified as a Curve A project; but undoubtedly it may be difficult to secure such a classification if the client is not agreeable.

"Different engineers may have different ideas about the classification of the same project. The engineer himself can best deal with this subject, since after all the principal purpose of the 'Recommendations' is to assist engineers in securing adequate fees, the engineer himself being most competent to pass upon the adequacy of compensation, bearing in mind the work and cost involved for the engineer, the responsibilities to be assumed by him, and the value of the service to be rendered to the client."

## Retirement of Eleanor H. Frick

Because of ill health, Miss Eleanor H. Frick, for many years Office Manager of the Society at Headquarters, has found it necessary to ask retirement. In presenting her letter of resignation, she comments upon the thrilling experience of having had a definite part in the development of the Society. She goes on to recount her continuous pride and satisfaction in the privilege of service "under the leaders of the engineering profession as represented on the successive Boards of Direction and the association with the fine body of men and women serving on the staff."

ELEANOR H. FRICK, RETIRING OFFICE MANAGER

Replying on behalf of the Executive Committee and pointing particularly to the remarkable Society growth during Miss Frick's service, President Mead and Secretary Seabury replied on December 16:

"You had a very real and valuable part in making that growth possible. The meticulous care you have given every phase of the work which has come under your supervision has contributed definitely to the esteem in which the Society is held. You have had more to do than most people realize with the standing which the Society enjoys not only in this country but abroad. The conception you held of its traditions and ideals was translated into every detail of the work from the excellence of its publications to the spirit pervading its every human relationship. More than you yourself can realize, your personality has sustained and pervaded not only the staff under your leadership, but the very membership of the Society itself. You will be greatly missed."

Many members who have come in contact with Miss Frick during her 39 years of service, will bear witness to her efficiency and her high idealism in everything that pertained to the Society. No officer or member was more proud of it than she. It is of more than passing interest that she has seen the organization grow from 2,000 to 15,000 members.

## New Year Book to Appear on Time

RAPID PROGRESS is being made with material for the 1937 *Year Book*. The cover will be red this year so that it can be distinguished easily from its buff counterpart of 1936. The information in the book will be completely revised and brought up to date. A new section, "Honorary Members," has been added which contains the names of all those who have held membership in that distinguished grade since the founding of the Society in 1852. Eighty-nine members have attained this distinction, five having been added last fall.

A new style of type is being used for the alphabetical list of members. In addition all names will be printed in bold face, insuring greater contrast between name and address. It is believed that by this change individual names can be picked out more easily and quickly, and the book thus made more useful to the membership.

All changes of address and the names of all new members will be carried up to and including March 1, 1937. Those who may not yet have provided latest information to Headquarters should do so immediately to secure a correct listing.

# Highlights of Society Activities for 1936

## *As Indicated by Extracts from the Annual Report of the Board of Direction*

AGAIN, this year, reemployment is probably the most important item to be reviewed as affecting civil engineers, but it has not been a spectacular matter in any respect. Employment is more easily secured. Salaries are better and many of those who sought emergency federal service during the depths of the depression have again found opportunities under private enterprise. One detail seems to be particularly significant. Membership in the Society is recognized as of material value in the securing and holding of positions. Whether it be that the Society's reputation for high membership requirements is responsible or whether there is that intangible loyalty among Society members need not be determined at the moment. That Society membership is a definite asset is clearly demonstrated.

* * * *

A Director of Publicity has been added to the staff this year with definitely satisfactory results. Intensified and directed publicity has been accorded in the press to the services that civil engineers perform and their value to the public. It is particularly to these objectives that releases have been prepared from time to time and that letters have been written to those in key positions in the editorial and news departments of the public press. It has been called to their attention that it is the civil engineer who designs those structures, necessary to community life, and that to him also public officials look for analyses of the economic worthiness of such projected improvements. Clippings for the year total 12,890 column inches of press comments wherein reference is made to the Society and its members as such.

* * * *

A new technical activity has been initiated, or rather intensified, by the formation of a Technical Division termed the "Soil Mechanics and Foundations Division." This will constitute the eleventh of these agencies whereby the Society directs investigation into the several technical interests of civil engineers.

* * * *

One problem to which attention has been directed intensively during the year is the question of whether or not there shall be adopted the policy of allocating all members resident in the United States and its possessions to some one or other existing or to-be-formed Local Section. Opinions have differed. Under financial conditions which it seems must necessarily be imposed, some Local Sections indicate preference for the change. Others do not. The basic principle is the desire to make the Society more effectively valuable to its members wherever they may live and the belief that this can be done best through the medium of strengthened Local Sections.

* * * *

Three conferences of representatives from the Student Chapters have been held with astonishing attendance and interest. The excellence of the presentations made by the students on the topics of the agenda was the outstanding characteristic of the conferences. For the students in attendance there must have been also the inspiration of participating with others in the Society's affairs.

* * * *

Spontaneous conferences of Local Sections, of Student Chapters, or of Sections and Chapters combined, in areas where distances were not too great seem to have achieved great popularity in this past year. Twenty-seven such local conferences have been held, and at all, some provision has been made for their continuance in years to come.

* * * *

President Mead has devoted almost the entire year to the interests of the Society, traveling far and almost constantly. Covering other portions of the country, the Field Secretary has visited many places and represented the Society upon numerous occasions. Visits by Vice-Presidents and Directors to the gatherings of members within their respective Zones or Districts also have been frequent. Including those by certain staff members, the rather surprising total of 270 visits was made—practically the equivalent of one each week-day of the year.

* * * *

Membership in the Society is in a very satisfactory condition. At the close of the year it stood at 15,101. This is about 250 less than the largest membership the Society has ever enjoyed and is slightly in excess of last year's figure.

One of the reasons the membership has remained at these uniformly high figures during the past few years has been the policy of the Board of Direction to cancel dues, wholly or in part, for those loyal members who have contributed to the Society's support for long periods, but who more recently have found themselves unable to continue this support. The amount of dues remitted is in excess of $200,000 for the period of the depression and represents a total of approximately 11,000 cancellations. The total for the year is well towards that of the peak year of 1927, and there is every indication that 1937 will see a resumption of the hitherto persistent upward membership trend.

* * * *

The number of men placed during 1936 has averaged about 114 per month. The following table shows the registrations and placements in the three offices:

| MONTH | MEN REGISTERED | | | | MEN PLACED | | | |
|---|---|---|---|---|---|---|---|---|
| | New York | Chicago | San Francisco | Total | New York | Chicago | San Francisco | Total |
| January | 117 | 69 | 49 | 235 | 59 | 26 | 13 | 98 |
| February | 160 | 49 | 58 | 267 | 50 | 25 | 13 | 88 |
| March | 145 | 62 | 52 | 259 | 60 | 30 | 37 | 127 |
| April | 147 | 59 | 82 | 288 | 57 | 45 | 36 | 138 |
| May | 186 | 61 | 71 | 318 | 46 | 31 | 32 | 109 |
| June | 228 | 113 | 73 | 414 | 48 | 23 | 22 | 93 |
| July | 154 | 60 | 66 | 280 | 47 | 41 | 35 | 123 |
| August | 114 | 35 | 58 | 207 | 51 | 39 | 33 | 123 |
| September | 125 | 82 | 57 | 264 | 60 | 36 | 26 | 122 |
| October | 125 | 49 | 67 | 241 | 51 | 30 | 27 | 108 |
| November | 128 | 37 | 39 | 204 | 57 | 36 | 27 | 120 |
| December | 115 | 65 | 47 | 227 | 64 | 36 | 23 | 123 |
| Total | 1,744 | 741 | 719 | 3,204 | 650 | 398 | 324 | 1,372 |

* * * *

*Proceedings*—Members and others who took part in the preparation of these papers, reports, and the discussions thereon, totaled approximately 345.

*Civil Engineering*—A total of 143 main articles, and this includes abstracts and committee reports, were published during the year. Developing a recent addition to these pages, short biographical notes were given for 160 members recently deceased. The total number of items originated by the editorial staff or submitted by Society groups was 1,337, representing an increase of 45 per cent over the previous year.

* * * *

The attendance at the Reading Room during the year was 2,181.

* * * *

There are at present 58 Local Sections, the Kentucky Section approved by the Board of Direction on January 13, 1936, having been added during the year.

* * * *

MEMBERSHIP OF TECHNICAL DIVISIONS

| | |
|---|---|
| City Planning | 1,458 |
| Construction | 2,817 |
| Engineering-Economics and Finance | 660 |
| Highway | 2,234 |
| Irrigation | 1,022 |
| Power | 937 |
| Sanitary | 1,672 |
| Soil Mechanics and Foundations | 197 |
| Structural | 2,886 |
| Surveying and Mapping | 1,113 |
| Waterways | 973 |
| Total | 15,969 |

* * * *

There are at present 113 Student Chapters. The University of Maryland Chapter was organized during 1936.

[The complete Annual Report of the Board of Direction for 1936 will appear in the forthcoming February PROCEEDINGS.]

## Papers on Flood Control to Appear in March "Proceedings"

MOST OF THE March issue of PROCEEDINGS will be given over to a symposium on flood control, comprising the eight papers presented at the Pittsburgh Meeting of the Society in October 1936. Brief summaries of these papers appeared last month in CIVIL ENGINEERING, but because of their timeliness it has seemed advisable to republish them immediately in full, and thus initiate a thorough discussion of the subject.

The symposium is of wide scope. It includes detailed engineering descriptions of the eastern floods of 1936; traces the participation of the federal government in flood control from the time of the Swamp Land Acts; outlines the legal arguments in favor of federal participation; and reviews the economic aspects of flood control projects in general and the problems involved in developing a national flood-control policy. The recent recurrence of floods in the Ohio Valley has accentuated the importance of this subject, so that a lively discussion of the papers in the following months is anticipated.

## Final Ballot on Society Officers for 1937

*33 West 39th Street*
*New York, N.Y.*
*January 13, 1937*

*To the Eighty-Fourth Annual Meeting*
*American Society of Civil Engineers:*

The tellers appointed to canvass the ballot for officers of the Society for 1937 report as follows:

| | | |
|---|---|---|
| Total number of ballots received | | 3,606 |
| Deduct: | | |
| Ballots from members in arrears of dues | 14 | |
| Ballots not signed | 52 | |
| Ballots with illegible signature | 2 | |
| Ballots with printed signature | 2 | |
| Ballots from non-members | 1 | |
| Total withheld from canvass | | 71 |
| Ballots canvassed | | 3,535 |
| *For President* | | |
| Louis Clarence Hill | 3,526 | |
| Scattering | 5 | |
| Blank | 4 | |
| | 3,535 | |
| *For Vice-Presidents* | | |
| Zone II: | | |
| Lyle Frederick Bellinger | 3,473 | |
| Scattering | 14 | |
| Blank | 48 | |
| | 3,535 | |
| Zone III: | | |
| Roy Cotsworth Gowdy | 3,500 | |
| Scattering | 5 | |
| Blank | 30 | |
| | 3,535 | |
| *For Directors* | | |
| District 1 (two to be elected): | | |
| William James Shea | 3,478 | |
| Enoch Ray Needles | 3,475 | |
| Scattering | 14 | |
| Blank | 103 | |
| Total votes registered | 7,070 | |
| Total ballots canvassed | | 3,535 |

| | |
|---|---|
| District 2: | |
| Arthur Warren Dean | 3,504 |
| Scattering | 1 |
| Blank | 30 |
| | 3,535 |
| District 6: | |
| Roland Parker Davis | 3,500 |
| Scattering | 1 |
| Blank | 34 |
| | 3,535 |
| District 10: | |
| Thomas Keith Legaré | 3,500 |
| Scattering | 6 |
| Blank | 29 |
| | 3,535 |
| District 13: | |
| Thomas Elwood Stanton, Jr. | 3,505 |
| Scattering | 2 |
| Blank | 28 |
| | 3,535 |

*Respectfully submitted,*
V. T. BOUGHTON, *Chairman*

| | | |
|---|---|---|
| Irving B. Thorner | H. L. Hurd | Alfred R. Glock |
| A. H. Baker | T. Grahlman | Philip M. Parker |
| B. F. Biemann | Charles D. Thomas | Howard Holbrook |
| James McB. Webster | Charles W. Comstock | *Tellers* |

## Which Local Section of the Society Is the Oldest?

AN INTERESTING discussion has arisen on the question of which Local Section of the Society can lay claim to being the oldest. So far as the Year Book is concerned, of course, the palm goes unquestionably to San Francisco—"Constitution Approved by Board, 1905." And since that was the year in which the establishment of Local Sections was authorized by the Board, a strict constructionist would be likely to see that as the end of the matter.

However, the St. Louis Section is somewhat inclined to look upon the California group, at least unofficially, as considerably its junior. In the Biographical and Professional Record of S. Bent Russell, who is now entering on his fiftieth year of membership in the Society, there appears the following notation:

"In February 1888, an association was formed of St. Louis members of the American Society of Civil Engineers, this being the first association of local members of the Society. I was made secretary and held the position for many years."

The records of the Society indicate that in 1905 this organization passed a resolution to the effect that it was not desirable at that time to establish a Local Section in St. Louis. The local group, it was said, "has never met for the purpose of reading or discussing technical papers, but only for the discussion of business matters in connection with the National Society." Twenty-six meetings had been recorded up to that date. Nine years later the St. Louis Association became a Local Section in the manner prescribed by the Constitution.

If "unofficial" beginnings are to be taken into account, it would appear that at least one other Local Section might lay claim to seniority over San Francisco—though as a matter of days rather than years. The San Francisco organization came into being on April 28, 1905, while on April 8 of the same year an association of members of the Society had been formed at Kansas City. The latter group, however, did not become a bona fide Local Section until 1921. It would be interesting to know whether still other Sections can trace their origin to 1905 or earlier.

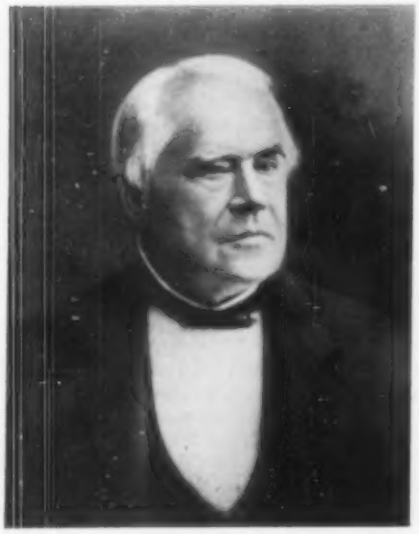
# Early Presidents of the Society

*This is the eleventh of a series of brief biographies of the men who guided the Society through its formative years. The next three issues will contain stories of Ashbel Welch, Charles Paine, and Don Juan Whittemore. Perhaps there are readers who have access to little-known facts or personal anecdotes about these engineers. If so, they are urged to take a part in making these records interesting and complete by communicating with Society Headquarters.*

## XI. JAMES BICHENO FRANCIS, 1815–1892

*President of the Society, 1880–1882*

JAMES BICHENO FRANCIS has been called the "maker of Lowell [Mass.]." And if any one man had a right to that designation, it was most certainly he. For forty years he managed the water power which made that city the largest manufacturing center of New England, served as adjudicator in disputes between the various mill owners, and was the recognized consulting engineer to every corporation in the town.



JAMES BICHENO FRANCIS
ELEVENTH PRESIDENT OF THE SOCIETY

To the engineering profession at large, of course, Francis' fame rests on his general contributions to experimental hydraulics. He developed and refined a method for measuring the flow of large streams, devised the weir formula that bears his name, laid the foundation for the development of the modern mixed-flow turbine, and perfected the apparatus and technique of turbine testing.

Francis was born in England in 1815. He came to America at the age of 18, after having been employed for several years with his father on railroad and harbor work in Wales. His first work in this country was under Maj. G. W. Whistler, on the Stonington (Conn.) Railroad, an extension of the Boston and Providence Railroad. When Whistler was selected in 1833 as engineer for the Proprietors of Locks and Canals on the Merrimack River, he took Francis to Lowell with him as a draftsman.

The development of Lowell was largely in the hands of this progressive organization. After the Pawtucket Canal, built in 1792 to carry boats around the falls of the Merrimack, had ceased to justify itself as a navigation venture, the Proprietors turned their attention to its power possibilities. By 1834 a large number of cotton mills and manufactories of other sorts were established along its banks, and among them was a machine shop, built and operated by the Proprietors themselves for the production of general mill machinery. This shop was enlarged in 1834 to handle the construction of locomotives, and Major Whistler was put in charge of it.

That was the beginning of locomotive building in New England. The Proprietors imported a Stephenson locomotive from England to serve as a model. Young Francis was assigned the task of dismembering it, part by part, and preparing working drawings of it for the machinists.

He did not work long as a draftsman, however. Within a year he was entrusted with much of the design and oversight of the Boott Cotton Mills, then under construction. This was a job that called for considerable ingenuity and originality. At that time precedents were few, and as one writer has said, "that rare quality, judgment, had often to bear greater responsibility than in the tenfold greater structures of the present." Yet Francis was then but nineteen years of age.

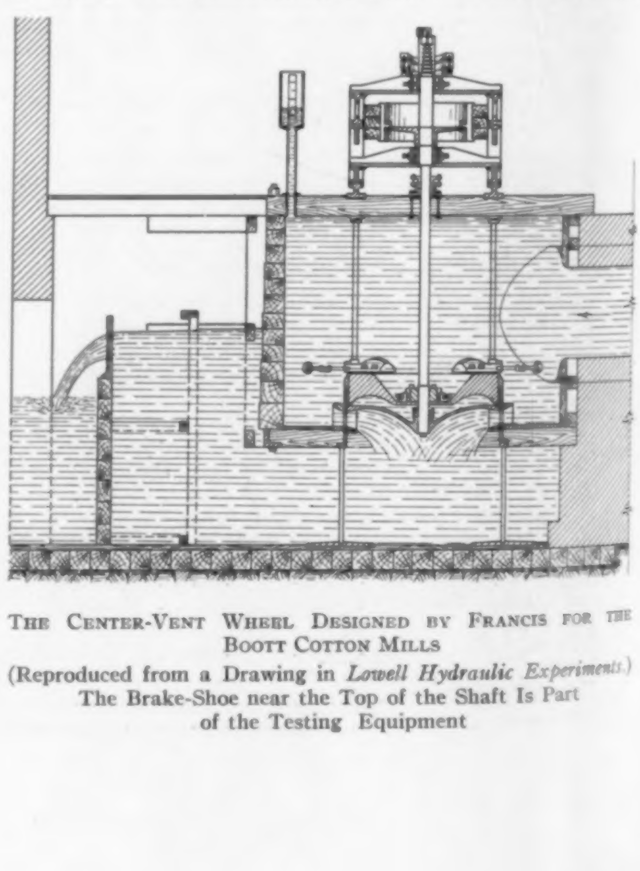
In 1837 Whistler returned to the Stonington Railroad and Francis took his place as engineer for the Proprietors of the Locks and Canals. In 1845 he became, in addition, their "agent," or general manager, with full authority to manage the entire system. Evaluated in horsepower, the development under his control would today be far from impressive. But in the middle of the nineteenth century it was the most important of its kind in the world. Along the Merrimack there had been developed at that time half as much water power as in the whole of France, and the larger part (roughly 9,000 hp) was concentrated at Lowell. It is in terms of such a comparison that his work must be judged.

At Lowell there was a unique opportunity for large-scale work in experimental hydraulics, and Francis made the most of it. It early became necessary to determine accurately the amount of water distributed to the various mills for their daily operation. Measurements on such a scale had never been made before with any attempt at refinement, and the working out of a proper method required considerable originality and not a little expense. The first investigations were not actually under the direction of Francis, but as he was in charge of the details a description of them is not out of place. The quotations are from a report made in 1841:

At a convenient spot in the Western Canal "we excavated the earth from the sides and formed a basin about 80 ft across . . . and raised the bottom so as to leave a depth only about 4 ft 6 in. We there placed across the canal seven paddle wheels, 16 ft in diameter and 10 ft long each, with narrow and solid piers between them, and coupled the shafts. . . ." The wheels were accurately fitted, and had but little clearance either at the piers or on the underlying timber apron. The latter was curved to the same radius as the wheels, so that as they revolved all the flow passed "by successive buckets full" through the device. Knowing the depth of water above the apron, the observers could easily compute the volume of water contained in each bucket. A device for counting the revolutions completed the equipment for gaging the stream.

Obviously so unwieldy a device could not be set up at every point where it was necessary to measure the discharge. The purpose of these precise measurements was to determine a correction factor to be applied to observations taken with a surface float. Within a few years, however, it became evident that the latter method was subject to too many sources of error to be depended on when such large financial interests were involved.

Consequently, in 1852 Francis adopted and refined another method long known to hydraulicians—the use of tube-shaped floats, weighted at one end so as to ride vertically and thus provide a measure of the average velocity along a vertical element in the stream. This scheme required another set of correction factors,



THE CENTER-VENT WHEEL DESIGNED BY FRANCIS FOR THE BOOTT COTTON MILLS
(Reproduced from a Drawing in *Lowell Hydraulic Experiments*)
The Brake-Shoe near the Top of the Shaft Is Part of the Testing Equipment

and therefore another set of accurate measurements of discharge.

It was decided this time to make the control measurements by means of weirs—and since Francis was unwilling to rely on weir formulas that were based on studies of very small models, he

IN 1848 LOWELL TOWNSPEOPLE DUBBED THIS EMERGENCY CANAL GATE "FRANCIS' FOLLY"

But Twice Since Then It Has Saved the Town from a Devastating Inundation. This View Was Taken When the Flood of 1936 Was near Its Crest

proceeded first to investigate the phenomena of weir discharge on a large scale, using weirs up to 10 ft in length, and measuring the dicharge in a lock chamber. The result of these studies was the well-known "Francis formula." Later investigators, with more data at their disposal, have perhaps devised formulas that give better results over a wide range of conditions, but none has ever seen fit to challenge the accuracy of Francis' experimental work.

And Francis himself would doubtless shudder at some of the uses to which his formula has been put. He clung closely to experiment, and constantly stressed the danger inherent in applying empirical relationships far outside the range of conditions for which they were derived—a point that even present-day researchers are sometimes prone to overlook.

During the 1840's the design of the water wheel began to undergo a great transformation. Until that time the breast wheel was considered as almost ideal. It had been built in large sizes—at Lowell, for example, there were eight such wheels with a diameter of 30 ft, and with buckets 12 ft long. But the breast wheel was slow and inefficient. In the earlier days, of course, efficiency was of little importance; water power was plentiful, and there were few places where it was necessary to develop all the power of a stream.

However, at Lowell the situation had begun to change. Water was not to be had for the asking, and the mill owners began to put a premium on performance. Turbines of various designs began to appear, for some of which the makers claimed exhorbitant efficiencies. In the following years Lowell became the center for both the design and testing of turbines, and in both fields Francis took an important part.

The first inward-discharge reaction wheel was patented by Samuel B. Howd, of Geneva, N.Y., in 1838. It was a crude affair in many respects, but embodied the principle of centripetal flow. Howd's agents sold the manufacturing rights for Middlesex County to the Proprietors of Locks and Canals, and Francis undertook its redesign on a scientific basis. In 1849 he built for the Boott Mills a center-vent wheel that gave an efficiency of almost 80 per cent. The use of the true "Francis" wheel was never widespread, but its design was the foundation on which the modern wheel was built.

There has been some discussion of the propriety of referring to modern wheels as "Francis type," and the suggestion has been made that they should more properly bear the name of Howd. The facts of the case are, however, that only a short time after Howd patented his inward-flow wheel he fell victim to the popular superstition about the advantages of centrifugal flow, and went back to making the older, outward-flow type. He even published an advertising circular in which he explained at great length why he had changed his mind. Had it not been for Francis the development of the modern turbine might have been delayed for many years. It was he who recognized its value, refined it, and presented it to the world. Perhaps if absolute justice were to be insisted upon, the modern wheel would have to be designated by some such compound appelation as Howd-Francis-Boyden-Swain, and even that would be to ignore the contributions made to its development by a hundred nameless millwrights.

An account of most of Francis' experimental work is contained in his book *Lowell Hydraulic Experiments*—a volume that should be on the reading list of every engineering student. It marks the beginning of a new era in the literature of hydraulic engineering, and is still recognized as a standard authority. For clear expository writing it reaches a degree of excellence that is seldom attained.

Francis did not confine his research to hydraulics. He was probably the first person in America to conduct tests on large cast-iron beams, and on the deflection of continuous beams. He carefully assembled and analyzed all existing data on column tests, and published the first comprehensive tables on column design. In 1849 he went to England to study methods of preserving timber, and on his return built a kyanizing plant at Lowell.

Loss from fire was a terrific hazard in the days of wooden mill buildings. He early gave this problem his attention, and designed a system of water supply for fire protection that was in operation in Lowell long before anything equally complete was to be found elsewhere. As a result, the annual fire loss in the Lowell district was for many years but half that in the other manufacturing centers of New England.

Francis resigned the office of agent and engineer of the Locks and Canals in 1885, and was succeeded by his son. On this occasion his friends presented him with a silver service, adding to their expressions of trust and friendship the declaration that "to the eminent ability and wisdom which have distinguished your administration, the marked success of the Lowell manufacturers has been largely due." He continued to serve the company as consulting engineer until his death, September 18, 1892.

The people of Lowell have only recently had cause again to be thankful for Francis' ability and wisdom. The flood of 1936 might easily have destroyed a large part of the city had it been able to cut through the center of the city by way of the Pawtucket Canal. That eventuality was prevented by a wooden emergency gate at the headworks, built by Francis 88 years before. For 84 years it had been hanging unused in its cradle. Early on the morning of March 19, 1936, a crew of workmen cut the wrought-iron shackle that held it, and with a splash it dropped straight to the sill. The water continued to rise against it, until it stood 26 ft deep on the upstream side; but the gate held, and Lowell was saved.

Francis was an active member of several scientific organizations. In 1848 he helped to found the Boston Society of Civil Engineers. Years later he served as its president, and in 1891 became an honorary member. In the American Society of Civil Engineers his career was similar—he was elected to membership at its first meeting, in 1852, was made president in 1878, and honorary member in 1892. He was also a member of the American Academy of Arts and Sciences and one of the incorporators of the Massachusetts Institute of Technology. In non-technical fields he was also active. At various times he served as a member of the Massachusetts Legislature and of the Lowell city government.

[Sources of information include: "The Boston Society of Civil Engineers and Its Founder Members," by John B. Babcock, 3d, M. Am. Soc. C.E. (*Journal, Boston Soc. C.E.*, July, 1936); "The Francis Gate at Lowell," by S. Stanley Kent (ibid, October 1936); "Great Hydraulic Engineers of New England's Classic Period," by Charles W. Sherman, M. Am. Soc. C.E. (*Engineering News-Record*, September 24, 1931); and "The American Mixed-Flow Turbine and Its Setting," by Arthur T. Safford, M. Am. Soc. C.E., and Edward Pierce Hamilton (*Transactions*, Vol. 85, 1922). Attention should be called to the Francis collection at the present offices of the Locks and Canals, which includes, bound in permanent form, his voluminous correspondence over half a century.

The photograph was furnished by Mr. Safford. To him and to Professor Babcock acknowledgment is also due for general assistance in the preparation of this article.]

# Society Publications Complete Successful Year

*Excerpts from Report to Board of Direction by Its Committee on Publications*

IN POINT OF quantity, the pages printed in both PROCEEDINGS and CIVIL ENGINEERING constitute an appreciable increase over those of the preceding year.

As to the general acceptability of the material published in PROCEEDINGS, opinion will doubtless depend on the technical interest of the individual member. Practically all technical papers are voluntarily contributed and are unsolicited. Each is anonymously subjected to the careful scrutiny of reviewers—averaging in number 4.4 per paper—who report their conclusions to the Committee, which then decides whether the article shall be accepted or declined, the year's record in this regard being as follows:

| | |
|---|---|
| Total papers considered | 97 |
| Accepted for PROCEEDINGS | 50 |
| Transferred to other uses | 3 |
| Declined | 37 |
| Held for reconsideration | 7 |

In determining acceptance, the Committee has made an effort to maintain some relation between the amount of material published in the various technical fields with the interest in these fields as indicated by the relative membership of the Technical Divisions, but owing to the voluntary contributions of subject matter, with only limited success. Thus, the following table shows the relative distribution of Technical Division membership and of papers accepted from January 1930 to date and from May 1935 to date:

| Technical Division | Technical Division Membership | Distribution in "Proceedings" and "Transactions" | |
|---|---|---|---|
| | | Jan. 1930 to Dec. 1936 | May 1935 to Dec. 1936 |
| City Planning | 9.8% | 2.2% | 0.8% |
| Construction | 17.7 | 9.8 | 6.5 |
| Eng.-Economics and Finance | 3.8 | 6.5 | 5.0 |
| Highway | 14.6 | 6.9 | 2.4 |
| Irrigation | 6.4 | 18.1 | 19.3 |
| Power | 5.8 | 15.2 | 14.2 |
| Sanitary Engineering | 10.7 | 7.9 | 8.9 |
| Structural | 18.3 | 23.9 | 31.6 |
| Surveying and Mapping | 6.8 | 2.0 | 1.3 |
| Waterways | 6.1 | 7.5 | 10.0 |
| | 100.0% | 100.0% | 100.0% |

It will be noted that the percentage of structural and irrigation papers accepted are much in excess of the percentage of membership in these Divisions. Criticism has reached the Committee that too much structural analysis has been printed, and a well-known structural engineer has expressed the opinion that many of the papers offered are "merely rearrangement of old devices"; but your Committee can only adjust to a limited degree the disproportion of voluntarily offered material.

Whether or not a better distribution of subject matter might be obtained through greater initiatory action of the Technical Divisions is believed worthy of consideration. There are those who believe that the best papers emanate from authors inspired by their subject. On the other hand, the value of coordinated papers and selected authors has been well illustrated during the past year by a symposium of 12 articles on the "Structural Application of Steel and Light-Weight Alloys" presented at the Pittsburgh Meeting after preprinting in the October PROCEEDINGS.

### VALUE OF MANUALS EMPHASIZED

The meeting of the Technical Procedure Committee in Pittsburgh emphasized the value to the membership of Manuals and registered the intention of the Technical Divisions to provide material for a considerable number of additional Manuals. Manual No. 14, "Definitions of Surveying Terms", has already been prepared for publication, and along similar lines, manuscripts on "Sludge Digestion" and "Filter Sand for Water Works" have been approved for publication in PROCEEDINGS as progress reports. At the present time, all manual material originating in committees of the Technical Divisions has been approved for publication.

As a result of a generous offer from a group of the so-called Freeman Scholars to furnish condensed translations from several foreign languages of various papers on hydraulic subjects, six of these translations have now been submitted, and it is anticipated that these valuable abstracts can be published in some single issue of PROCEEDINGS during the latter part of the coming year. In this project the Society Committee on Hydraulic Research has been actively interested.

What are believed to be improvements during the present year include the adoption of a heavier and better quality text paper and cover for PROCEEDINGS, a similar paper for the forthcoming 1937 *Year Book*, and more attractive covers for CIVIL ENGINEERING.

During the year 5,000 copies of CIVIL ENGINEERING were distributed free to members of Student Chapters with an invitation to subscribe at a minimum charge, with relatively small response in subscriptions, but with some probable return in advertising value.

### PUBLICATION OBJECTIVES ARE BEING REALIZED

Your Committee believes that CIVIL ENGINEERING is making good progress toward the fulfilment of the objectives of its creators in 1930, which as stated in its first issue, included the publication in attractive form of the less highly technical papers, an opportunity for the stimulation of divisional and committee activities and an advertising medium through which manufacturers could inform the membership of their products and "an outlet for material dealing with professional activities as the means of making the Society a more dynamic force in the non-technical and professional relations of the engineer."

For several years past, Committees on Publications have realized the importance of adding to the personal and human interest and popular appeal of CIVIL ENGINEERING, and during the past year the number of items in the sections devoted to "Society Affairs," "Items of Interest," and "News of Engineers" have been expanded about 50 per cent, and provision has been made for additional Local Section news through the 42 junior correspondents appointed by various Local Sections. Starting with April, brief biographies of Past-Presidents have been presented in each issue.

In furtherance of the originally recorded objective to make CIVIL ENGINEERING a dynamic force in the non-technical and professional relations of the engineer, your Committee has given serious consideration to the publication in each issue of a signed leading article devoted to subjects of general professional and public relation interest, and it is proposed to start this series in the February issue.

That the manufacturers have accepted CIVIL ENGINEERING as a profitable medium is indicated by a total advertising income for 1936 in excess of $38,000—an increase of 25 per cent over that of the previous year. During seven months of 1936, advertising volume exceeded or equaled the previous high record.

A comparison of the total and net costs of publications in 1929—the year before the initiation of CIVIL ENGINEERING—with those of the past year, is of interest. It appears that the advertising income from CIVIL ENGINEERING, together with various savings, has made possible a reduction of 10 per cent in the net cost of publications from 1929–1936.

### APPRECIATION OF TECHNICAL REVIEWERS

No report of a Committee on Publications can fail to acknowledge continued indebtedness to the members of the Society who undertake the review of technical papers, on which reviews depend the maintenance of the standard of technical material published. At the present time, 1,034 individuals are registered as available for this self-sacrificing and most valuable service.

*Respectfully submitted,*

F. A. BARBOUR, *Chairman*

CHARLES B. BURDICK EDWARD P. LUPFER
JAMES K. FINCH C. E. MYERS

*January 17, 1937*

# Unemployment in the Engineering Profession

*Second Release of Data from Survey of the Engineering Profession Conducted by the U. S. Bureau of Labor Statistics*

*The second article of the series reporting the analysis of the returns from a Survey of the Engineering Profession appeared in the January issue of the "Monthly Labor Review," published by the federal Bureau of Labor Statistics. It was prepared by A. F. Hinrichs, chief economist, and Andrew Fraser, Jr., of the Bureau's Division of Wages, Hours, and Working Conditions. The following abstract and excerpts from that article relate particularly to the information about civil engineers among the 52,589 engineers who replied to the questionnaire. A similar résumé of the first article, concerned with the education of the engineer, appeared in the August 1936 issue of "Civil Engineering." Other articles will follow as released by the Bureau.*

In May 1935, a Survey of the Engineering Profession was undertaken by the Bureau of Labor Statistics at the request of American Engineering Council. From this survey it is now possible to report on the unemployment experienced by the engineering profession between the end of 1929 and the end of 1934.

The following summary analysis of unemployment, including work relief and direct relief, may be presented:

1. Between the end of 1929 and 1932, the precentage of engineers who were unemployed increased from 0.7 to 10.9. At the end of 1934 the percentage was 8.9.
2. At no time was direct relief extensive among engineers, but the development of work-relief programs after 1932 became an important factor.
3. The largest number of unemployed at any one time was about 11 per cent of the total, but more than a third of the engineers had some period of unemployment within the 5 years, 1930–1934.
4. Among those who became unemployed at some time during these 5 years, half were out of employment (except as they found work relief) for more than a year.
5. This experience with unemployment was common to all professional classes of engineers.
6. The most marked differences as regards unemployment are those found among the various age groups. The greatest frequency of unemployment was among those who attempted to enter the profession after 1929. Approximately half of them were unemployed at one time or another from 1930 to 1934.
7. When the older engineers became unemployed, however, unemployment lasted longer than it did with the younger engineers. Thus, the median period of unemployment for engineers graduating in 1925–1929 was 12.1 months, whereas the median for those graduating prior to 1905 was 23.1 months.
8. The effect of this longer period of unemployment among older engineers was cumulatively to produce a higher percentage of unemployment among older engineers than among younger engineers. Thus, in December 1934, 11.5 per cent of the engineers 53 years of age or more were unemployed, in contrast to an average of 7.3 per cent of the younger engineers who were exposed for the same period to the risk of possible unemployment.
9. The type of education the professional engineer had received did effect variations in both the incidence and severity of unemployment. These factors were very much less for postgraduates than for engineers with other types of education. But as between engineers with first degrees in engineering and those whose college course was incomplete or who had attended non-collegiate technical schools, the differentials were very slight.
10. The influence of regional location on unemployment was practically negligible, whether considered from the point of view of differentials in incidence or of severity of unemployment.

### Scope and Method of Study

In the August 1936 issue of Civil Engineering, on pages 540 and 541, there were reproduced cuts showing the complete questionnaire used in the Survey of the Engineering Profession. Questions 6 and 7 of the questionnaire, the replies to which are the sources of these data, can be summarized as follows:

"Question 6. Employment: The bureau is tracing the change in engineering opportunities since 1929. Please indicate your major occupation by using a check in the appropriate space to indicate an affirmative answer to describe your status at the end of each of the 3 years, 1929, 1932, and 1934.

"Items *a* to *d*, inclusive, engineering activity.

"Item *e*, non-engineering work.

"Item *g*, any other employment.

"Items *f*, *h*, and *i*, respectively, work relief, wholly unemployed, and direct relief.

"Question 7. Unemployment and relief (during 60 months from January 1, 1930, to December 31, 1934):

"*a*. Number of months totally unemployed.

"*b*. Number of months on work relief or CWA.

"*c*. Number of months on direct relief."

The answers to these questions were correlated with (1) type of education, (2) professional class, (3) age, and (4) regional location. The total numbers of engineers in the various classes are not shown in this article but will become available in the final bulletin to be published later as a federal document.

### Incidence and Duration of Unemployment Among Professional Engineers, 1930–1934

Question 7 asked the number of months during the period January 1, 1930, to December 31, 1934, that the engineer (*a*) was totally unemployed, (*b*) was on work relief or CWA, or (*c*) was on direct relief.

At one time or another within these five years more than 35 per cent of all the engineers reporting were unemployed at one time or another. Table I shows that for all graduates combined, including those with postgraduate degrees, no less than 37.8 per cent experienced unemployment.

Unemployment was greatest among the newcomers to the profession and decreased with the age of the engineer. The engineers in the two younger groups were exposed to a shorter period of risk of unemployment, a factor which is of importance when the

Table I. Percentage Distribution, by Age and Type of Education, of All Engineers Reporting a Period of (Gross[1]) Unemployment, 1930–1934

| Item | Age (in Years) in 1934 | College Graduates: % Reporting Unemployment |
|---|---|---|
| All graduating classes | | 37.8 |
| Entered profession during 1930–1934: | | |
| Graduated in— | | |
| 1933–1934 | 23–24 | 47.1 |
| 1930–1932 | 25–27 | 53.5 |
| Entered profession in 1929 or earlier: | | |
| Graduated in— | | |
| 1925–1929 | 28–32 | 36.0 |
| 1915–1924 | 33–42 | 27.1 |
| 1905–1914 | 43–45 | 23.8 |
| Prior to 1905 | 53+ | 23.5 |

| Item | Age (in Years) in 1934 | Other Engineers with: College Course Incomplete | Non-Collegiate Technical Course |
|---|---|---|---|
| | | % Reporting Unemployment | |
| All years | | 35.4 | 35.6 |
| Entered profession during 1930–1934: | | | |
| Born in— | | | |
| 1910–1914 | 20–24 | 47.9 | 48.2 |
| 1905–1909 | 25–29 | 49.5 | 49.8 |
| Entered profession in 1929 or earlier: | | | |
| Born in— | | | |
| 1900–1904 | 30–34 | 39.0 | 41.4 |
| 1895–1899 | 35–39 | 33.4 | 34.1 |
| Prior to 1895 | 40+ | 30.4 | 32.3 |

[1] Includes periods both of direct relief and work relief. The term "work relief" is used as excluding work on PWA projects as well as non-relief administrative positions in the public service.

length of their employment is considered. They were also subjected to the necessity of making their way into the profession under singularly difficult conditions.

The engineers who entered the profession before 1930 had a common experience as regards the period during which they were exposed to the risk of unemployment. The largest percentage of unemployment occurred among those who entered slightly before the beginning of the depression.

These findings as regards the extent of unemployment among engineers in general are confirmed by analysis of the separate professional classes of engineers shown in Table II.

Table II shows that for the country as a whole approximately two-fifths of the civil engineers reported some unemployment within the five years covered, whereas slightly more than one-third so reported in the other professional classes. Of the engineers with college degrees, the highest was 41.8 per cent for civil, agricultural, and architectural engineers. Among those with an incomplete college course, 39.1 per cent of the civil engineering group reported unemployment. At all ages civil engineers showed the greatest unemployment.

TABLE II. PERCENTAGE DISTRIBUTION, BY AGE AND PROFESSIONAL CLASS,[1] OF GRADUATE AND COLLEGE-INCOMPLETE ENGINEERS REPORTING A PERIOD OF GROSS UNEMPLOYMENT[2] 1930–1934

| Graduating Class or Year of Birth | Age (in Years) in 1934 | Percentage Reporting Unemployment Graduate Engineers: Chemical and Ceramic | Civil, Agricultural, & Architectural | Electrical | Mechanical & Industrial | Mining & Metallurgical |
|---|---|---|---|---|---|---|
| All graduating classes | . . . | 33.5 | 41.8 | 36.9 | 35.0 | 33.9 |
| Entered profession during 1930–1934: | | | | | | |
| Graduated in— | | | | | | |
| 1933–1934 . . . | 23–24 | 40.3 | 55.1 | 48.9 | 40.7 | 45.6 |
| 1930–1932 . . . | 25–27 | 44.3 | 59.7 | 54.7 | 48.5 | 54.7 |
| Entered profession in 1929 or earlier: | | | | | | |
| Graduated in— | | | | | | |
| 1925–1929 . . . | 28–32 | 29.8 | 41.9 | 31.3 | 34.2 | 33.7 |
| 1915–1924 . . . | 33–42 | | 34.4 | 19.6 | 25.4 | |
| 1905–1914 . . . | 43–52 | 15.1 | 26.8 | 17.2 | 24.7 | 23.9 |
| Prior to 1905 . . | 53+ | | 27.0 | 17.1 | 23.3 | |
| | | Engineers with College Course Incomplete | | | | |
| All ages . . . . . . | . . . | [3] | 39.1 | [3] | 31.2[4] | [3] |
| Entered profession during 1930–1934: | | | | | | |
| Born in— | | | | | | |
| 1910–1914 . . . | 20–24 | [3] | 55.9 | [3] | 41.8[4] | [3] |
| 1905–1909 . . . | 25–29 | [3] | 57.3 | [3] | 42.0[4] | [3] |
| Entered profession in 1929 or earlier: | | | | | | |
| Born in— | | | | | | |
| 1900–1904 . . . | 30–34 | [3] | 43.5 | [3] | 34.4[4] | [3] |
| 1895–1899 . . . | 35–39 | [3] | 37.8 | [3] | 29.3[4] | [3] |
| Prior to 1895 . . | 40+ | [3] | 33.3 | [3] | 26.3[4] | [3] |

[1] It should be noted that in the case of all graduate engineers, it was necessary to make certain combinations of professional classes. Thus, a small number of ceramic engineers were combined with chemical engineers. Civil, agricultural, and architectural engineers were combined, but the group was dominated by civil engineers. Mechanical and industrial engineers were combined, as were also mining and metallurgical engineers. In the case of the "other" engineers there were too few cases of non-collegiate technical school graduates to warrant tabulation of the period of unemployment by both age and professional class; hence, only the data for those whose college course was incomplete are tabulated. This group has been divided to distinguish civil, agricultural, and architectural engineers from mechanical and all other types of engineer. Inasmuch as the unemployment experience of civil engineers differed from that of all other classes, this grouping into two categories makes possible general comparisons between the unemployment experience of graduate engineers and those with an incomplete college course.

[2] Includes periods both of direct relief and work relief.

[3] Included with mechanical and industrial.

[4] Includes chemical and ceramic, electrical, and mining and metallurgical.

### Periods of Unemployment

"Gross unemployment" is used in this section to cover periods of work relief or periods without work of any kind. The figures show the median periods of unemployment, in other words the middle point, half of the engineers having had a longer period and half a shorter period of unemployment.

In connection with the age classification shown in Table III, it is important to remember the period of exposure to the possibility of unemployment.

The professional class to which engineers belonged had a less marked influence on the average period of unemployment than either age or educational background.

As to education, for the country as a whole the median period of unemployment for engineers who were college graduates was 11.4 months. For engineers who did not complete their college course it was 16.3 months, and for those with a non-collegiate technical education it was 17.3 months.

TABLE III. MEDIAN PERIOD OF GROSS UNEMPLOYMENT,[1] BY AGE, TYPE OF EDUCATION, AND PROFESSIONAL CLASS, 1930–1934

| Graduating Class | Age (in Years) in 1934 | Period of Gross Unemployment (in Months) of Graduate Engineers: All Classes | Chemical & Ceramic | Civil, Agricultural & Architectural | Electrical | Mechanical & Industrial | Mining & Metallurgical |
|---|---|---|---|---|---|---|---|
| All graduating classes . . . . . | . . . . | 11.4 | 9.4 | 11.8 | 11.5 | 11.1 | 12.3 |
| Entered profession during 1930–1934: | | | | | | | |
| Graduated in— | | | | | | | |
| 1933–1934 . . | 23–24 | 7.5 | 7.0 | 7.9 | 7.7 | 7.1 | 6.0 |
| 1930–1932 . . | 25–27 | 11.9 | 10.6 | 11.9 | 13.2 | 11.1 | 11.9 |
| Entered profession in 1929 or earlier: | | | | | | | |
| Graduated in— | | | | | | | |
| 1925–1929 . . | 28–32 | 12.1 | 11.1 | 12.2 | 12.4 | 12.0 | 11.7 |
| 1915–1924 . . | 33–42 | 13.4 | | 12.9 | 14.1 | 15.2 | |
| 1905–1914 . . | 43–52 | 17.8 | 11.4 | 17.0 | 20.7 | 18.5 | 17.4 |
| Prior to 1905 . | 53+ | 23.1 | | 22.9 | 25.3 | 22.2 | |

| Year of Birth | Age (in Years) in 1934 | Period of Gross Unemployment (in Months) of Other Engineers: College Course Incomplete: All Classes | Civil, Agricultural & Architectural | Mechanical & Others | Non-collegiate Technical Course |
|---|---|---|---|---|---|
| All ages . . . . . | . . . | 16.3 | 15.8 | 16.9 | 17.3 |
| Entered profession during 1930–1934: | | | | | |
| Born in— | | | | | |
| 1910–1914 . . | 20–24 | 12.5 | 13.8 | 11.4 | 15.0 |
| 1905–1909 . . | 25–29 | 14.0 | 13.9 | 14.3 | 15.3 |
| Entered profession in 1929 or earlier: | | | | | |
| Born in— | | | | | |
| 1900–1904 . . | 30–34 | 14.2 | 13.2 | 15.1 | 16.0 |
| 1895–1899 . . | 35–39 | 14.6 | 14.1 | 15.3 | 14.7 |
| Prior to 1895 . | 40+ | 19.4 | 18.3 | 22.0 | 19.2 |

[1] Includes periods both of direct relief and work relief.

The average length of the period of unemployment increased with age. The older engineer suffered from unemployment because of its greater length when it occurred rather than because of its greater frequency.

Up to this point the discussion has referred only to median periods of unemployment. The full breadth and depth of the situation is much more dramatically reflected in the lengths of the varying periods of unemployment, shown in Table IV. For the entire group of graduates prior to 1930 who reported unemployment, 6,965 in number, the range was from 21 per cent who were out of work for less than six months to 3.2 per cent who were unemployed for four years or more. It will be well to ponder these specific figures in the light of the previous finding in this article, that more than 35 per cent of the 52,589 engineers reporting were out of work at some time during these four years, and that more than 40 per cent of the civil engineers had that unhappy experience.

### Unemployment at End of 1929, 1932, and 1934

The previous section of this discussion dealt with the number of months between January 1, 1930, and December 31, 1934, that engineers were on relief work or were without work of any kind. This section will be concerned with trends in unemployment as disclosed from the answers to Question 6, which is of the spot type of questionnaire. It asked the individual to report his major occupation on three specific dates, December 31, 1929, December

21, 1932, and December 31, 1934. By this method there were secured samples which indicate trends in unemployment.

It may be remarked here that because of the arbitrary selection of these particular dates, it seems to be almost a certainty that they did not coincide with the moment when engineering employment was at its worst. December 1932 was certainly deep in the valley of the depression; how much worse the simultaneous unemployment of engineers may have been before or after that date may never be adequately determined. The data for three chosen dates certainly indicate the trend.

Table IV. Percentage Distribution of Engineers Graduating from College Prior to 1930, by Period of Unemployment

| Year of Graduation | Total Reporting in Survey | Total Reporting Unemployment at Any Time During 1930–1934: Number | Total Reporting Unemployment at Any Time During 1930–1934: Per Cent | Percentage Whose Reported Unemployment (in Months) Was: Under 6 | 6 and Under 12 | 12 and Under 18 | 18 and Under 24 | 24 and Under 30 | 30 and Under 36 | 36 and Under 42 | 42 and Under 48 | 48 and Over |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| All years prior to 1930 | 24,853 | 6,965 | 100.0 | 21.0 | 21.6 | 16.5 | 12.8 | 9.5 | 7.1 | 5.1 | 3.2 | 3.2 |
| 1925–1929 | 6,499 | 2,340 | 100.0 | 23.9 | 25.7 | 19.4 | 13.4 | 7.9 | 4.0 | 3.2 | 1.6 | 0.9 |
| 1915–1924 | 8,298 | 2,245 | 100.0 | 23.3 | 22.9 | 16.1 | 11.4 | 9.4 | 7.3 | 4.4 | 3.0 | 2.2 |
| 1905–1914 | 6,602 | 1,570 | 100.0 | 17.7 | 18.8 | 14.0 | 13.8 | 11.4 | 8.7 | 7.2 | 3.7 | 4.7 |
| Prior to 1905 | 3,454 | 810 | 100.0 | 12.8 | 11.7 | 14.4 | 13.1 | 10.6 | 12.0 | 8.3 | 7.0 | 10.1 |

For the country as a whole, and without regard to professional class or type of education, Table V shows that the proportion of engineers unemployed on December 31 rose from 0.7 per cent in 1929 to 10.9 per cent in 1932 and then declined to 8.9 per cent in 1934.

The decrease in unemployment among engineers from 1932 to 1934 must not be thought to imply an increase in the proportion engaged in engineering employment. The gain occurred in non-engineering work, which increases were particularly important to electrical engineers. Only in the case of mining and metallurgical engineers was there a large increase in the percentage reporting engineering unemployment.

Disregarding educational background, the most striking fact in Table V is the narrow range in the proportions of unemployment among the various professional groups for each of the three periods.

The type of education the engineer had received affected the extent of unemployment. Thus in 1932 the proportion of all postgraduates who were unemployed was only two-thirds that of graduates with a first degree in engineering. The smallest difference occurred among civil engineers.

The outstanding feature of Table VI is that on December 31, 1934, there remained unemployed a larger proportion of the oldest group of engineers than of all the younger groups (except the youngest, non-graduates 23 to 24 years of age or graduates during 1933–1934). In the table the engineers are classified on the basis of their age in 1934.

Further inspection of these columns in Table VI shows very clearly that by December 1934 many of the older engineers were still unable to obtain work; and there is a very strong presumption that the preference in new hirings was given to the younger men. This is partly explicable on the grounds that, first, the older engineers were probably in a better position financially to weather the continuing depression, and second, that the available professional employment opportunities were of such a nature as not to be in keeping with their experience or their customary salary status.

It should be noted here that criticism has been made that the percentages of unemployment shown in the table for the oldest group of engineers relate to the indefinite group of those "53 and over." The figures would presumably be smaller if the group were closed at 62 years of age. It is quite certain from the contour of the percentages, both in 1932 and 1934, that the percentage continues to rise with age. It is also certain that the high percentages shown are due to the persistence of unemployment when it occurs, rather than to a rising risk of unemployment.

Table VI also shows evidence of the improved employment opportunity for younger men between the end of 1932 and 1934.

These findings are borne out by the other columns of the table, in which the same type of information is presented for each of five professional groups of engineers.

In summary, this analysis of trends shows (1) that there was a distinct improvement in the employment status of professional engineers between December 31, 1932, and December 31, 1934; (2) that there were but slight differences in the incidences of unemployment among the various professional classes in 1932 and, except for civil engineers, in 1934; (3) that engineers who had received postgraduate degrees fared better than engineers with other types of training; and (4) that as between older and younger engineers, the former not only felt the effect of the drop in business activity earlier than the latter but were still lagging, at least until December 31, 1934, in the return to professional activity.

In general it may be said that in this period of contraction of business activity the inexperienced newcomer had greater difficulty in securing a professional status than any other class, and that those with 5 to 25 years of experience fared best as regards unemployment.

### Work Relief and Direct Relief Among Professional Engineers, 1929 to 1934

In this survey, work relief is defined as emergency employment usually made available on the basis of need by such agencies as CWA, FERA, and WPA. It does not include engineering work on PWA projects which should have been reported either as a form of private employment or as government employment for those engineers working in the Public Works Administration itself. It

Table V. Percentage of Engineers of Each Professional Class Unemployed[1] on December 31, 1929, 1932, and 1934, by Type of Education

| Professional Class | 1929: All Types of Education | 1929: Post-graduates | 1929: First Degree Graduates | 1929: Others With: College Course Incomplete | 1929: Others With: Noncollegiate Technical Course | 1932: All Types of Education | 1932: Post-graduates | 1932: First Degree Graduates | 1932: Others With: College Course Incomplete | 1932: Others With: Noncollegiate Technical Course | 1934: All Types of Education | 1934: Post-graduates | 1934: First Degree Graduates | 1934: Others With: College Course Incomplete | 1934: Others With: Noncollegiate Technical Course |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| All engineers | 0.7 | 0.5 | 0.7 | 0.9 | 1.1 | 10.9 | 8.1 | 11.5 | 10.4 | 11.1 | 8.9 | 6.3 | 9.1 | 10.3 | 10.0 |
| Chemical and ceramic | 0.5 | ... | 0.4 | 1.6 | ... | 10.1 | 6.5 | 11.3 | 7.9 | 25.0 | 6.8 | 3.2 | 7.7 | 5.8 | 23.8 |
| Civil, agricultural, and architectural | 0.7 | 0.5 | 0.7 | 0.8 | 1.4 | 10.5 | 9.4 | 10.8 | 10.2 | 11.7 | 10.8 | 9.6 | 10.9 | 11.9 | 13.3 |
| Electrical | 0.8 | 0.8 | 0.3 | 0.6 | 1.4 | 11.6 | 8.5 | 12.5 | 9.6 | 10.3 | 8.0 | 5.7 | 8.2 | 9.3 | 8.6 |
| Mechanical and industrial | 0.7 | 0.5 | 0.8 | 0.9 | 0.4 | 11.3 | 6.4 | 11.8 | 11.9 | 10.5 | 7.5 | 4.5 | 7.9 | 8.2 | 6.3 |
| Mining and metallurgical | 2.1 | 0.7 | 2.1 | 2.1 | 3.8 | 10.9 | 9.3 | 12.0 | 8.3 | 9.6 | 8.3 | 7.0 | 8.8 | 8.4 | 11.2 |

The column heads under each year are "Percentage[2] Unemployed on December 31:".

[1] Including those on direct relief and work relief.

[2] The total numbers of engineers in the various classes are not shown in this article. It may be noted, however, that the number of engineers reporting employment in 1934 was 48,124 as against 40,721 in 1932, owing to the entrance of new persons into the profession. The number reporting unemployment on December 31, 1934, was 4,288 as against 4,448 on December 31, 1932—a decline of less than 4 per cent. Therefore the total numbers reporting unemployment on these two dates should not be compared, because of the over-representation of recent college graduates in the sample and the high percentage of unemployment among them.

also does not include engineers hired for strictly administrative work by the various relief administrations. There was some over-reporting of work relief and a corresponding under-reporting of public employment.

Direct relief refers to direct financial or other assistance from any public authority.

TABLE VI. PERCENTAGE OF ENGINEERS IN EACH PROFESSIONAL CLASS UNEMPLOYED[1] ON DECEMBER 31, 1929, 1932, AND 1934, BY AGE OR YEAR OF GRADUATION

| APPROXIMATE AGE IN 1934 OF ENGINEERS, OR YEAR OF GRADUATION[2] | PERCENTAGE UNEMPLOYED ON DECEMBER 31: | | | | | |
|---|---|---|---|---|---|---|
| | All Professional Classes | Chemical & Ceramic | Civil, Agricultural, & Architectural | Electrical | Mechanical & Industrial | Mining & Metallurgical |
| | 1929 | | | | | |
| 53 years of age and over, and graduates prior to 1905 . . | 1.9 | 0.7 | 1.7 | 2.2 | 1.8 | 3.6 |
| 43 to 52 years of age, and graduates during 1905–1914 . . | 0.7 | 0.5 | 0.9 | 0.3 | 0.6 | 2.2 |
| 33 to 42 years of age, and graduates during 1915–1924 . . | 0.4 | 0.5 | 0.4 | 0.3 | 0.2 | 1.3 |
| 28 to 32 years of age, and graduates during 1925–1929 . . | 0.4 | 0.3 | 0.3 | 0.4 | 0.6 | 0.5 |
| 25 to 27 years of age, and graduates during 1930–1932 . . | ... | ... | ... | ... | ... | ... |
| 23 to 24 years of age, and graduates during 1933–1934 . . | ... | ... | ... | ... | ... | ... |
| | 1932 | | | | | |
| 53 years of age and over, and graduates prior to 1905 . . | 10.9 | 3.9 | 11.2 | 10.0 | 11.3 | 12.8 |
| 43 to 52 years of age, and graduates during 1905–1914 . . | 8.7 | 7.0 | 8.8 | 7.1 | 9.6 | 9.6 |
| 33 to 42 years of age, and graduates during 1915–1924 . . | 8.0 | 5.0 | 8.9 | 6.6 | 8.7 | 6.0 |
| 28 to 32 years of age, and graduates during 1925–1929 . . | 10.6 | 8.8 | 10.2 | 9.9 | 11.9 | 12.4 |
| 25 to 27 years of age, and graduates during 1930–1932 . . | 16.6 | 15.8 | 14.7 | 20.2 | 15.6 | 17.5 |
| 23 to 24 years of age, and graduates during 1933–1934 . . | ... | ... | ... | ... | ... | ... |
| | 1934 | | | | | |
| 53 years of age and over, and graduates prior to 1905 . . | 11.5 | 5.9 | 12.3 | 11.4 | 10.2 | 14.2 |
| 43 to 52 years of age, and graduates during 1905–1914 . . | 8.1 | 4.1 | 9.0 | 7.3 | 7.7 | 7.5 |
| 33 to 42 years of age, and graduates during 1915–1924 . . | 7.0 | 4.4 | 8.9 | 5.5 | 6.0 | 6.2 |
| 28 to 32 years of age, and graduates during 1925–1929 . . | 7.0 | 5.5 | 9.2 | 5.3 | 6.0 | 7.5 |
| 25 to 27 years of age, and graduates during 1930–1932 . . | 8.0 | 4.9 | 11.5 | 6.9 | 5.8 | 6.1 |
| 23 to 24 years of age, and graduates during 1933–1934 . . | 13.9 | 11.9 | 18.0 | 14.6 | 10.4 | 10.7 |

[1] Including those on direct relief and work relief.

[2] In order to obtain a datum whereby direct comparisons could be made between engineers with and without degrees, the median age of graduation among the several professionals was computed. This was found to be 23 years. Consequently, the data were so tabulated to permit of groupings by years of graduation and corresponding year of birth for each of the periods 1929, 1932, and 1934. In this table engineers with college degrees in the years indicated are combined with "other" engineers of the ages given in the table.

Considering first the spot information at the close of 1929, 1932, and 1934, the first data to be considered are with reference to direct relief. Fewer than one per cent of the engineers reported themselves to have been unemployed on December 31, 1929. At that time there were no work-relief projects and none of the engineers reported themselves as on direct relief.

TABLE VII. PERCENTAGE OF GRADUATE ENGINEERS, BY YEAR OF GRADUATION AND PROFESSIONAL CLASS, REPORTING WORK RELIEF AT ANY TIME, 1930–1934

| YEAR OF GRADUATION | PERCENTAGE REPORTING WORK RELIEF | | |
|---|---|---|---|
| | Civil Engineers | Electrical Engineers | Mechanical Engineers |
| All years . . . . . . . . | 18.3 | 9.3 | 8.7 |
| 1933–1934. . . . . . . . | 26.4 | 12.5 | 10.2 |
| 1930–1932. . . . . . . . | 25.2 | 12.8 | 10.4 |
| 1915–1920. . . . . . . . | 15.9 | 6.2 | 7.4 |
| Prior to 1915 . . . . . . | 12.4 | 6.3 | 7.6 |

Nearly 11 per cent of all engineers reported themselves as unemployed on December 31, 1932; 31 engineers reported themselves as on direct relief—less than one-tenth of 1 per cent of all the engineers, or only half of 1 per cent of the number reporting unemployment.

For the five-year period as a whole, receipt of some direct relief was reported by 0.8 per cent of all engineers with college degrees and about 2 per cent of those who attended non-collegiate technical schools or who did not complete their college course. It may be noted here that in New York City direct relief appears to have been more extensive through the Professional Engineers' Committee on Unemployment than through public agencies.

Engineer's training was required in the administration of many of the projects designed to benefit other groups in the community. There was also a large increase in non-relief forms of public employment. This was of particular benefit to civil engineers, of whom 8.5 per cent were employed by the federal government on December 31, 1929, and 18.6 per cent were so employed on December 31, 1934. For civil engineers the increase in this form of employment was greater than the increase in work relief.

Despite the increase in public employment, work-relief projects were the main possibility for absorbing unemployed engineers. On December 31, 1932, when nearly 11 per cent of the engineers were unemployed, only 0.7 per cent were on work relief. Two years later 4 per cent of all engineers were on work relief, which was approximately half of the total number of engineers unemployed at that time; that is, one-third of the unemployed engineers were thus absorbed.

The reports for December 31, 1934, show striking differences in the extent of work relief as between civil engineers and the other professional groups. At that time, 6.6 per cent of all civil, agricultural, and architectural engineers were on work relief as compared with only 2.3 per cent of all the other professional classes combined. The difference undoubtedly reflects chiefly the development of work programs that called especially for the civil engineer's training; it also reflects the fact that the total amount of unemployment among civil engineers in their normal fields increased from 1932 to 1934, whereas it decreased in the other professional classes.

Work relief was slightly more common among engineers without college degrees than among those who were college graduates.

Comparison of the proportions on work relief at the close of 1932 and 1934 indicates that more of the older engineers were so employed prior to 1932, while the more recent graduates predominated in such work in 1934. This was especially true of the civil engineers.

Examining the five-year period as a whole, for all types of engineers, irrespective of background, about one-eighth reported some period of work relief, as that word is to be understood, but very wide differences were shown in the extent of work relief for civil engineers and for other types of engineers.

In all professional classes, age was an important factor in the frequency of work relief. Table VII gives the percentages of those reporting work relief at any time during the five years 1930–1934 for the three professional classes of civil, electrical, and mechanical engineers classified by age. The figures relate only to college graduates. The civil engineers here tabulated do not include architectural and agricultural engineers nor do the mechanical engineers include industrial.

TABLE VIII. MEDIAN PERIOD OF WORK RELIEF AMONG GRADUATE ENGINEERS, 1930–1934, BY YEAR OF GRADUATION AND PROFESSIONAL CLASS

| YEAR OF GRADUATION | MEDIAN PERIOD (IN MONTHS) OF WORK RELIEF | | |
|---|---|---|---|
| | Civil Engineers | Electrical Engineers | Mechanical Engineers |
| All classes . . . . . . . . | 5.0 | 4.4 | 4.9 |
| 1933–1934 . . . . . . . . | 4.1 | 3.8 | 4.1 |
| 1930–1932 . . . . . . . . | 4.8 | 4.3 | 4.5 |
| 1915–1929 . . . . . . . . | 5.6 | 4.6 | 5.7 |
| Prior to 1915 . . . . . . | 5.5 | 6.5 | 5.6 |

The median period of work relief was approximately five months, as shown in Table VIII, for college graduates classified by year of graduation in the three professional groups of civil, electrical, and mechanical engineering. The shorter period in the case of the younger classes is consistent with the earlier conclusion that recruitment was more extensive among this group of engineers than among the older ones.

# Assembly of American Engineering Council Meets

American Engineering Council held its Seventeenth Annual Assembly at the Mayflower Hotel in Washington, D.C., January 14, 15, and 16. At the meeting were most of the representatives of the seven national engineering societies, the 14 state societies, and the 27 local engineering associations, societies, and clubs, which compose the members of the Council.

The purpose of American Engineering Council is to provide the means for the unification of the engineering profession in viewpoint, thought, and action on social and economic questions without interfering with the specialized technical field or with the autonomy of member engineering societies. It is, in effect, an unbiased nonpartisan organization of engineering organizations, unmoved by anything but the desire to serve the public good in an advisory capacity. It accepts the responsibility of fostering clear thinking by engineers on public questions, of promoting factual analysis of engineering economic problems, and of publicizing the resulting engineering opinion for public benefit. Its factual information is made available to its member organizations and to both the legislative and administrative branches of government—federal, state, and local.

The officers for 1937 remain as for 1936, those whose terms expired with this meeting being reelected for another term. They are: president, Andrey A. Potter, American Society of Mechanical Engineers; vice-presidents, Alonzo J. Hammond, American Society of Civil Engineers; Ralph E. Flanders, American Society of Mechanical Engineers; John S. Dodds, representing local and state associations; and Carroll O. Bickelhaupt, American Institute of Electrical Engineers; treasurer, Charles E. Stephens, American Institute of Electrical Engineers; and executive secretary, Frederick M. Feiker.

On Thursday, January 14. preceding the sessions of the Assembly itself, there was an all-day conference of the secretaries of member engineering societies. President Potter opened the conference with an address on "Uniting Engineers in Their Public Responsibilities," which was followed by papers on the interrelationship between engineering organizations; on publicity for the engineering profession; on the need for public affairs committees in local societies; on registration; on successful local society programs, with considerable emphasis on efforts to assist junior members with educational programs and discussion clubs. There followed a general roundtable discussion on the many problems faced by those who take part in managing and operating local engineering societies. The interchange of ideas promises to stimulate the secretaries to new effort on behalf of their organizations.

Thursday evening the delegates and secretaries met together at dinner, which was followed by a symposium on public affairs. It included an enlightening address on "Social Security, Old Age and Unemployment Compensation," which was delivered by Arthur J. Altmeyer, member of the Social Security Board, who gave opportunity to discuss some phases of this newly enacted legislation. This was followed by a résumé of the activities during the past three years of the Public Works Administration, by E. W. Clark, M. Am. Soc. C.E. The symposium closed with a graphic presentation of the growth and extent of power production in the United States, by Thomas R. Tate, of the Federal Power Commission. He pointed out that 1936 saw the all-time peak of electric power consumption and production.

Friday morning, January 15, the Assembly itself met in a business session to conduct the business of Council. The annual report of the executive secretary revealed that six additional engineering organizations had joined Council during 1936, bringing its membership to 48, the largest in its 17 years of existence. A budget based on an income of $40,000 was adopted. A report was heard from a committee which is making progress on patent legislation, designed to more adequately protect the small individual inventor. The report of the public works committee, also adopted, reiterated Council's previous stand recommending the grouping of all construction and engineering of the federal government, so far as practicable, in a single department under one qualified head.

Attention was directed again to the need for completing the mapping of the United States, and the committee explained that each local society should impress upon its representatives in Congress the value to their state of completing the mapping program therein.

Considerable time was given to the subject of conservation and utilization of lands, and to rural electrification, discussion of which developed what is being accomplished in reducing the construction costs of distribution lines and increasing the per capita consumption of electricity on farms. The importance of this effort is having a threefold effect, it was pointed out: It is increasing the market for electrified equipment for home and farm; it is improving the living conditions of our rural population; but most important of all, generally available electricity in rural districts will serve as an effective means of lifting and pumping water to agricultural lands, now dry-farmed and too frequently wind-eroded.

Thursday evening was the brilliant spot of the Assembly—500 engineers gathered together in the ballroom of the Mayflower Hotel for the annual all-engineers' dinner. Here were gathered engineers of the District of Columbia sections and chapters of a score of engineering societies. The meeting following the dinner was presided over by Dean A. A. Potter, president of American Engineering Council, with Donald H. Sawyer, M. Am. Soc. C.E., as master of ceremonies. At the speakers' table sat the officers of Council, the presidents of the Founder Societies, and the speakers.

A dramatic event was the presentation of honorary membership in the American Society of Mechanical Engineers to Rear Admiral Hutchinson I. Cone, formerly engineer-in-chief of the U. S. Navy. He was presented to President James H. Herron of the American Society of Mechanical Engineers by M. X. Wilberding, chairman of the District of Columbia section of that society.

As an introduction to the engineer's part in national defense, Rear Admiral Harold G. Bowen, engineer-in-chief of the U. S. Navy, presented a revealing paper on the vast variety and amount of engineering that goes into the construction of the Navy's ships and of its floating and shore establishments. The nation with the best engineering in its navy will win any engagement, he declared. Warfare is one gigantic engineering effort.

Although the author himself was absent as a result of temporary illness, the meeting was not denied Dr. Charles F. Hirshfeld's philosophical paper, "The Engineer of Today and Tomorrow." It was eloquently presented by R. L. Sackett, M. Am. Soc. C.E., of Pennsylvania State College. [This paper was abstracted in the January 1937 issue of Civil Engineering.]

A fine oratorical treat of the evening was the address by Senator Joseph C. O'Mahoney, Wyoming, on "Interstate Regulation of Business by Federal License." Interest in the speakers' subjects was attested by the close attention given to them, even at the close of a long evening. The dinner closed at 11 p. m.

Saturday morning, January 16, saw the closing up of the business of Council with discussion centering on publicity for the profession, on the merit system in government, and on engineering economics.

# In and About the Society

The Student Chapter at Pennsylvania State College keeps its members informed of its various activities by means of a biweekly mimeographed sheet, the "Penn State Tripod, "which is distributed at each meeting of the Chapter. Interesting and humorous personal items are interspersed among more serious announcements to stimulate interest and insure its being thoroughly read. This little publication is now in its seventh year, and the masthead, carrying out the figure suggested by the name, reads "Set-Up No. 7, Shot No. —."

* * * *

On January 9 the executive committee of the Conference of the Maryland–District of Columbia Student Chapters of the Society held its first annual meeting at George Washington University in Washington. Two delegates from each of the participating universities were present, and Robert A. Jackson, of the University of Maryland, was elected chairman of the executive committee, and T. Ritchie Edmonston, of George Washington University, secretary. It was decided that the next Student Chapters conference in that area should be held in Baltimore on April 19, with the Johns Hopkins University Student Chapter acting as host. During the business session it was also decided that each Chapter should send at least one representative to the Annual Meeting of the Society.

# Preview of Proceedings

*By* HAROLD T. LARSEN, *Editor*

*The schedule for the February issue of "Proceedings" promises to be an unusually full one, containing papers on draft tubes, rainfall frequencies, the expansion of rails, and the economics of bridge floors. In addition, it will include the annual report and numerous valuable critical comments on current papers.*

### ECONOMICS OF HIGHWAY BRIDGE FLOORINGS OF VARIOUS UNIT WEIGHTS

A means of determining, in a very few minutes and quite accurately, the comparative economics of any two or more types of modern highway bridge flooring is offered in a paper entitled "Economics of Highway Bridge Floorings of Various Unit Weights" by J. A. L. Waddell, Hon. M. Am. Soc. C.E. The basic requirements for the problem are that the designer shall know the thickness of the floor deck and its weight per square foot, the weight per square foot of floor lying between the stringers and the flooring, and the cost per square foot of flooring in place. In compiling this material, Dr. Waddell has drawn generously from his private records and his wide experience as a practicing engineer and has fashioned it for use with the skill inherent in one who has been a thorough student in the design aspects of his profession throughout his career. The paper contains numerous graphs, from which the designer can pick the value he needs as the occasion arises.

There is a great lack of the kind of information that is contained in this paper. Bridge designers are interested in the comparative costs of various types of floors now on the market. They are also interested in the structural efficiency, the wear, the maintenance, and weight of these floors, and the effect upon weight of supporting structural units. In this paper, as in all others published in PROCEEDINGS, questions concerning specific comparisons between commercially patented products are not involved. Instead, a consistent effort has been made to avoid "seeming to advocate special interests," with the understanding that the discussers likewise will confine their comment to the intended scope.

### FLOW CHARACTERISTICS IN ELBOW DRAFT TUBES

At a joint meeting of the Irrigation and Power Division held at Vancouver, B.C., on July 12, 1934, a paper entitled "Flow Characteristics in Elbow Draft Tubes" was presented by C. A. Mockmore, M. Am. Soc. C.E. A very brief description of this paper was published subsequently in the September 1934 issue of CIVIL ENGINEERING. The tests and material from which the former paper was prepared, supplemented by extensive subsequent research, form the basis of this thoroughly prepared report on flow characteristics. The paper describes work on this subject conducted at the State University of Iowa, at Princeton University, in the U. S. Department of Agriculture, at the Oregon State Agricultural College, and in the U. S. Engineer Office at Portland, Ore., which was responsible for the tests on models of Bonneville Dam.

This paper deals in part with the flow of water in pipe bends, in which the inlet and outlet cross-sections are essentially of equal area, and in part with the flow of water in the draft-tubes which, by definition, are expanding conduits. The author places special emphasis on the flow around the bent part of the tube. The first part of his paper deals primarily with the designing and building of different types of bends of a transparent material, tests being made with Pitot tubes for velocities and pressures at various points in the cross section. Measurements were made to determine pressures for various rates of flow with the idea of finding out which bend offered the least resistance to the flowing water.

The tests indicated that the pipe which was flattened in the direction of the plane of the bend offered less resistance to flow than any of the others, regardless of cross-sectional area. It also appeared that the distance between the inside and outside walls at the outlet of the bend of an elbow draft tube, should be small compared to the gross diameter of the tube. In concluding the paper, Professor Mockmore makes the following suggestions as a basis for designing the cross-sections of a bend of an elbow draft tube: (1) At 0 deg (the beginnng of the bend), use a circular cross-section; (2) at $22^1/_4$ deg, use an elliptical section with the major axis of the ellipse normal to the plane of bend; (3) at 45 deg, use an ellipse of greater eccentricity for the inside than for the outside of the section; and (4) at the end of the bend, use a rectangular section.

### RAINFALL INTENSITIES AND FREQUENCIES

Hydraulic engineers who are confronted with local problems involving scant authentic local records will be interested in reading the forthcoming paper by A. J. Schafmayer, M. Am. Soc. C.E., and the late B. E. Grant entitled "Rainfall Intensities and Frequencies." In this paper a means is developed for analyzing the records other than those supplied by local rain gages. The primary object of this analysis was to determine the validity, or otherwise, of using multiple data from many rain gages. Obviously, if this is correct procedure the applicable hydrological data are increased many times. From such an analysis, the authors return to the local data with more adequate information than they would otherwise have had. For example, all the available records of excessive rainfall published by the U. S. Weather Bureau for 19 cities were first examined, and those exceeding certain rates were tabulated and plotted on logarithmic paper. It was noted that the curves were remarkably straight and regular in their arrangement. The next step was to select the data from 10 cities of the original 19, denoting a similar regularity and consistency in the resulting curves. Finally, the application of data from 14 rain gages in Chicago, Ill., is described, as is the use of such data in defining curves and formulas for use by engineers of the city of Chicago. The formulas for intensity of rainfall were found to be rectangular hyperbolas that could be plotted on a specially designed semi-hyperbolic paper as straight lines. The tabular data which support the curves of this paper are particularly valuable in themselves. The authors believed that this method of using multiple data is valid, when used with judgment.

### TEMPERATURE STRESS AND EXPANSION OF RAILS

A subject of special interest to engineers engaged in railway track work is being published in the February issue of PROCEEDINGS under the title "Temperature Stress and Expansion of Rails," by Alfred Africano, Jun. Am. Soc. C.E. He presents a theory and illustrated examples for determining the expansion in long continuous rails. One of the implications of the theory is that only 100 ft or so of the more expensive part of this track is needed at each end of a continuous rail of 1,000 or even 2,000 ft in order to restrain the remaining length against expansion. A number of railroad companies are showing marked interest in the possibility of using long continuous welded rails, a case in point being the tests by the Delaware and Hudson Railroad at Mechanicville, N.Y., a view of which is shown in the accompanying photograph.

CONTINUOUS, WELDED RAILS, ONE-HALF MILE LONG, ON THE DELAWARE AND HUDSON RAILWAY AT MECHANICVILLE, N.Y.

### THE ANNUAL REPORT

In addition, there will be the regular annual report, which customarily appears in the February issue of PROCEEDINGS. Comments on this year's report will be found elsewhere in this issue.

# Papers Filed in Library

THE FOLLOWING papers have recently been deposited for reference in the Engineering Societies Library, 29 West 39th Street, New York. The price of photostatic reproduction will be quoted by the library on request.

### Least Squares for Undergraduates

GOODWIN, RALPH E., M. Am. Soc. C.E., "Least Squares for Undergraduates" (8,800 words, 3 figures). No new formulas are presented, but the standard ones are developed by new methods that the author has found to be of practical value in teaching the subject to beginners. "It is quite in the tradition of teaching," he says, "that least squares should be unintelligible to students. They are bewildered by the opening act of legerdemain in which the probability curve is plucked out of the air. . . . It is believed the principles involved can be made intelligible to beginners if certain explanations are introduced and certain stumbling blocks removed."

### Grouting Contraction Joints at Boulder Dam

HAYS, J. B., M. Am. Soc. C.E., "Grouting Contraction Joints at Boulder Dam" (9,900 words, 12 figures, 24 photographs). To avoid cracks due to shrinkage of the concrete in Boulder Dam, the huge mass was constructed in rows of columns whose vertical joints might take the place of cracks due to contraction. After the concrete had been cooled by circulating refrigerated water through it, these joints, which had opened wider in the interim, were grouted under pressure to unite the columns into a monolith. Mr. Hays describes in detail the grouting methods and equipment which he developed in the course of the work. The effectiveness of these methods was evidenced by 500 ft of core borings covering as wide a range of joint conditions as possible. An abstract of the paper appears in this issue of CIVIL ENGINEERING.

### Moving Loads on Beams with Restrained Ends

BRUMFIELD, R. C., M. Am. Soc. C.E., "Moving Loads on Beams with Restrained Ends" (15,000 words, 11 figures). Eight criteria are developed for loading a span to produce maximum bending moments in beams whose ends are restrained. Part I of the paper deals with beams of constant moment of inertia. General formulas are derived, and the resulting criteria are plotted in the form of curves. The case of a fixed-spacing loading extending over the support into two spans is discussed. Part II treats beams of variable section in the same manner. Methods are given for readily solving for the moment functions of the unit-span-moment triangles, which are shown to be fundamental to all moment diagrams. Illustrative problems are included in both parts.

# News of Local Sections

### Central Illinois Section

At the annual meeting of the Central Illinois Section the following officers were elected for 1937: Wilbur M. Wilson, president; R. L. Whannel, vice-president; and R. P. Hoelscher, secretary-treasurer.

### Central Ohio Section

The Central Ohio Section was host to the Ohio State University Student Chapter at a meeting held at the Faculty Club on the campus of the University in Columbus on December 10. The guest of honor and principal speaker was Daniel W. Mead, President of the Society. Among the other guests present were H. S. Morse, Director of the Society; W. D. Turnbull, acting dean of the college of engineering at Ohio State University; and W. R. E. Baxter, director of publicity for the Society. One of the features of the occasion was the installation of the following officers for 1937: W. H. Knox, president; R. B. Jennings, first vice-president; and P. W. Holstein, Jr., secretary-treasurer. There were 101 present, of whom 45 were students.

### Cleveland Section

The annual dinner meeting of the Cleveland Section was held on January 6 in the Colonial Room of the Cleveland Chamber of Commerce. Following dinner, committee reports were read and the following officers were unanimously elected: A. F. Blaser, president; F. L. Gorman, vice-president; and J. H. Anderson, secretary-treasurer. The speaker of the evening was Bennett Chapple, vice-president of the American Rolling Mill Company, whose subject was "New Frontiers of Business." Among the forty present were five members of the Ohio Northern University Student Chapter.

### Colorado Section

On December 14 the Colorado Section held its annual meeting, at which the following officers were elected for 1937: E. B. Debler, president; R. L. Downing, vice-president; and P. S. Bailey, secretary-treasurer. The feature of the occasion was a talk by John H. A. Brahtz, engineer in charge of the photoelastic laboratory of the U. S. Bureau of Reclamation. Mr. Brahtz spoke on "The Photoelastic Apparatus in Theory and Application," illustrating his talk with instruments and materials from the Bureau of Reclamation.

### Connecticut Section

There were 30 present at the fall meeting of the Connecticut Section, which was held at the Graduate Club in New Haven on December 4. A brief report on the Fall Meeting of the Society was given by Harold L. Blakeslee, president of the Section; and Joseph P. Wadhams, secretary-treasurer of the Section, gave an account of the engineers' meeting held at Connecticut State College in October. The technical program consisted of a talk by Sanford H. Wadhams, director of the Connecticut State Water Commission. An interesting and instructive discussion followed.

### Dayton Section

At the annual meeting of the Dayton Section, which was held on December 23, officers for 1937 were elected as follows: B. T. Schad, president; E. O. Brown, first vice-president; G. V. Clow, second vice-president; and C. H. Stephens, secretary-treasurer. The speaker of the occasion was Edmund B. O'Leary, of the school of business at the University of Dayton, who gave a talk on the subject, "Money, Credit, and Prices." There were 15 present at the meeting.

### Georgia Section

On December 14 the Georgia Section of the Society held a meeting, at which officers for the coming year were elected. The list of these is as follows: J. W. Barnett, president; F. C. Snow, vice-president; B. H. Hardaway, Jr., non-resident vice-president; and A. J. Cooper, secretary-treasurer. It was decided that, during the remainder of the year, all members of the Georgia Institute of Technology Student Chapter are to be admitted to Section affairs at half price. A talk was then given on the topic, "Highway Materials and Testing," by J. E. Boyd, testing engineer of the Georgia State Highway Board.

### Illinois Section

Election of officers for 1937 took place at the annual meeting of the Illinois Section, which was held on December 11. The results were as follows: Albert Smith, president; Loran D. Gayton, vice-president; and John F. Seifried, treasurer. The 27 members and guests present heard Joseph Ross Lloyd, meteorologist of the U. S. Weather Bureau in Chicago, give an interesting talk. Mr. Lloyd, whose topic was "Back of the Weather Forecast," described the detailed observations that are made at two hundred stations. On December 9 the Section cooperated with five other engineering societies in sponsoring a joint meeting. These were the Western Society of Engineers, the American Institute of Architects, the Illinois Society of Architects, the Builders' Club, and the Chicago Engineers' Club. The speaker of the occasion was C. F. Goodrich, chief engineer of the American Bridge Company, who described many of the outstanding features of the San Francisco–Oakland Bay Bridge, illustrating his talk with slides and a sound motion picture of actual construction operations. There were approximately 800 present.

### Ithaca Section

A joint dinner meeting of the Ithaca Section and local branches of the American Society of Mechanical Engineers and the American

Institute of Electrical Engineers took place on November 20 in Willard Straight Hall, on the campus of Cornell University. There were 77 present. Following the dinner, D. B. Steinman, consulting engineer of New York City, addressed the group on the registration of engineers. On December 17 the Section held a dinner at the Mark Twain Hotel in Elmira, N.Y. At this session Benjamin K. Hough, Jr., an associate engineer in the Corps of Engineers, U. S. Army, gave an illustrated talk on the subject, "Investigation of Soils for Dam Construction," with special reference to the Passamaquoddy Project. There were 26 members and guests in attendance.

### Kansas City Section

There were 52 present at a dinner meeting of the Kansas City Section, which was held in the Hotel President on December 15. A feature of the business session was the annual election of officers, the results being as follows: T. D. Samuel, Jr., president; J. F. Brown, first vice-president; Ashley B. Taylor, second vice-president; and W. M. Spann, secretary-treasurer. A. C. Everham spoke on the Registration Bill for Architects and Engineers, to be brought before the next session of the Missouri state assembly. The technical program consisted of the presentation of a sketch on the "Professional Career of Octave Chanute," by Robert P. Woods, president of the Section, and the reading of a paper by J. A. L. Waddell on "Training for Engineers in Extemporaneous Speaking." In Dr. Waddell's absence the paper was read and discussed by E. E. Howard, consulting engineer of Kansas City.

### Kentucky Section

At the annual meeting of the Kentucky Section, which was held on December 15, the following officers were elected for 1937: F. C. Dugan, president; D. V. Terrell, vice-president; and W. B. Wendt, secretary-treasurer.

### Los Angeles Section

The new officers for the Los Angeles Section are as follows: Kenneth Q. Volk, president; Donald M. Baker and R. R. Martel, vice-presidents; and William C. Hogoboom, secretary. Mr. Hogoboom was elected for a two-year term, and the treasurer, Milo C. Halsey, carries over from last year, as that office is likewise for a two-year term.

### Louisiana Section

In October the Louisiana Section entertained Daniel W. Mead, President of the Society, at a special dinner meeting held in New Orleans. In addition to Dr. Mead, the speakers were C. S. Williamson, Jr., professor of chemistry at Tulane University; John F. Coleman, Past-President of the Society; B. W. Pegues, professor of civil engineering at Louisiana State University; Edward J. McNamara, president of the Tulane University Student Chapter; W. H. Rhodes, vice-president of the Louisiana Section; Alfred F. Théard, general superintendent of the Sewerage and Water Board of New Orleans; and Col. Edward S. Bres, contact member for the Tulane University Student Chapter. Clifford Stem, president of the Louisiana Section, acted as toastmaster.

### Maryland Section

At the annual meeting of the Maryland Section, which was held at the Engineers' Club in Baltimore on December 18, the following officers were elected for the coming year: H. H. Allen, president; Abel Wolman, vice-president; and J. J. Jenkins, Jr., secretary-treasurer.

### Metropolitan Section

An attendance of 500 at a meeting of the Metropolitan Section, held in the Engineering Societies Building in New York City on December 16, attested to the popularity of the symposium type of meeting. On this occasion three of the speakers principally responsible for the design and construction of the Midtown Hudson Tunnel gave illustrated talks. These were O. H. Ammann, chief engineer of the Port of New York Authority (which is in charge of the project), who discussed the general conception and development of the project; Ralph Smillie, engineer of design, who described the outstanding features of design, comparing them with similar features of the Holland Tunnel; and C. S. Gleim, engineer of construction, whose topic was the sinking of the caissons and the tunneling operations. On January 8 the Section held a joint meeting in cooperation with the Metropolitan Section of the American Society of Mechanical Engineers, the New York City Post of the Society of American Military Engineers, the Municipal Engineers of the city of New York, and the New York Chapter of the American Society of Landscape Architects. The New York World's Fair of 1939 was the subject of the meeting. The first speaker was Grover Whelan, president of the fair, who outlined its general aims and the benefits expected. Next Stephen F. Voorhees, chairman of the board of design, discussed the theme of the exposition, "Building the World of Tomorrow." In conclusion, John P. Hogan, chief engineer, described the engineering aspects of the fair. A surprising fact revealed was that the site chosen for it is within a mile and a half of the geographical center of Greater New York. There were about 800 present.

### New Mexico Section

The New Mexico Section elected its officers for 1937 at a meeting held in Albuquerque on December 15. The list is as follows: Frederic G. Healy, president; R. H. Rupkey, first vice-president; Thomas McClure, second vice-president; and William E. Strohm, secretary and treasurer. On September 11, 1936, the first regular fall meeting of the Section took place at the University of New Mexico. At this session Frederic Healy, one of the directors of the Section, gave an account of the Annual Convention of the Society, which was held in Portland. The speaker of the evening was Raymond Hill, consulting engineer and Director of the Society, who discussed the mistakes involved in the design of the spillways of the Mormon Flats, Horse Mesa Dam, and Roosevelt Dam. At a meeting of the Section held in Santa Fe on October 14, a talk was given by Harold Conkling, deputy state engineer of California. Mr. Conkling's subject, which was "Administrative Control of Underground Water," elicited enthusiastic discussion. On November 9 Daniel W. Mead, President of the Society, was entertained at a banquet given by the Section at the El Fidel Hotel. Dr. Mead was the speaker on this occasion, his subject being "Engineering Ethics."

### Oklahoma Section

On December 29 the Oklahoma Section held its annual meeting, at which the following officers for 1937 were elected: N. E. Wolfard, president; G. H. James, first vice-president; Frank Herrmann, second vice-president; and D. L. Wilson, secretary-treasurer. This was the last of four meetings held in 1936. The first took place in Oklahoma City on February 29. At this session H. S. Gillett, senior highway engineer in the U. S. Bureau of Public Roads, presented a paper on "Soil Examination, Analysis, and Tests." An enthusiastic discussion followed. Prior to a dinner meeting of the Section, which was held in Stillwater, Okla., on April 4, members inspected the buildings on the campus of the Oklahoma Agricultural and Mechanical College. Following dinner, there was a technical program consisting of talks by John E. Kirkham, professor of engineering research at the College, and J. C. Carpenter, senior highway engineer in the U. S. Bureau of Public Roads. On August 5 there was a dinner meeting in Oklahoma City, held in honor of Daniel W. Mead, President of the Society, and George T. Seabury, Secretary.

### Panama Section

There were 30 members and guests present at a dinner meeting of the Panama Section held at the Union Club in Panama City on December 14. During the business session the report of the nominating committee for 1937 officers was heard. These are as follows: E. P. Haw, president; E. Lyons, Jr., first vice-president; A. W. Brooks, second vice-president; and R. L. Klotz, secretary-treasurer. The speakers for the occasion were M. R. Alexander, assistant engineer, division of office engineer, The Panama Canal, who discussed the reconstruction of Lock 15 at Balboa; G. W. Green, who described the changed field conditions resulting from the revised design; and Maj. W. D. Styer, assistant engineer of maintenance on the project, whose topic was cofferdam design in general.

### Philadelphia Section

A joint meeting of the Philadelphia Section of the Society and of the local post of the Society of American Military Engineers was held in Philadelphia on December 16. This session was in charge of J. C. H. Lee, Lt. Col., Corps of Engineers, U. S. Army, and dis-

trict engineer of the Philadelphia Engineer District, who had arranged an unusual program. Following dinner, which was enjoyed by 80, the presentation of certificates of membership on the advisory board of the Philadelphia Engineer Procurement District took place. The purpose of this organization is to assist in industrial mobilization in time of national emergency. The speakers of the evening were C. L. Hall, Lt. Col., Corps of Engineers, U. S. Army; J. J. Manning, commander of the Public Works Department of the Philadelphia Navy Yard; L. D. Shuman, chief of operations of the Philadelphia Engineer District; Howard Ker, resident engineer on the Chesapeake and Delaware Canal; F. H. Kohloss, executive engineer of the Philadelphia Engineer Procurement District; C. W. Burlin, executive and disbursing officer for the Philadelphia Engineer District; and Colonel Lee. There were 200 at the meeting.

### Providence Section

There were 60 present at a meeting of the Providence Section held in the Providence Engineering Society Building on December 29. On this occasion a talk on "Soil Tests for the Passamaquoddy Project," was given by Waldo I. Kenerson, chief of the soils laboratory of the flood control division of the U. S. Engineers' office. In connection with his talk, Mr. Kenerson showed lantern slides of the Passamaquoddy Project and gave a demonstration of the apparatus used in making tests to ascertain the physical properties of the soil upon which the dams were to be built.

### San Diego Section

At the annual meeting of the San Diego Section, which took place December 23, the following officers were elected for the coming year: L. L. Mills, president; C. B. Neill, vice-president, and C. Wayland Capwell, secretary-treasurer.

### San Francisco Section

At the regular annual meeting of the San Francisco Section, which was held on December 15, the following officers were elected for the coming year: H. J. Brunnier, president; Ralph G. Wadsworth, vice-president; and T. J. Corwin, Jr., secretary-treasurer. All committees gave résumés of their activities during the past year, and the membership committee reported a substantial increase in membership, the total now being 541. The technical program was on the subject of the "Golden Gate International Exposition," and four members of the Section gave illustrated talks on the design and construction of the engineering features of this exposition. The first speaker was W. P. Day, vice-president of the exposition, and he was followed by Messrs. J. J. Walsh, J. J. Gould, and J. B. Leonard. There were 150 at the meeting.

### South Carolina Section

At a meeting of the South Carolina Section, held in Columbia, S.C., on January 7, the following officers were elected for 1937: James H. Dingle, president; Daniel T. Duncan, vice-president; and Albert E. Johnson, secretary-treasurer.

### Spokane Section

On December 11 the Spokane Section held its annual meeting at the Davenport Hotel. The feature of this occasion was the annual election of officers, which resulted as follows: John W. Howard, president; W. L. Malony, first vice-president; and Philip G. Holgren, second vice-president and secretary-treasurer.

### St. Louis Section

Following its usual custom, the St. Louis Section was host to the senior-class members of the various Student Chapters in Missouri at its annual meeting, which was held at the Statler Hotel on November 14. There were 86 present, 43 of whom were from Student Chapters at Washington University, the University of Missouri, and the Rolla School of Mines. Following dinner, a talk was given by F. G. Jonah, chief engineer of the Frisco Lines, on "The Development of Transportation." An open discussion followed. During the business session the annual election of officers took place. A list of these appeared in the January issue of Civil Engineering.

### Tacoma Section

There were 28 members and guests at the December meeting of the Tacoma Section, which was held at the Tacoma Hotel on the 7th. During the business session the report of the nominating committee for 1937 officers was heard, the results being as follows: Edward C. Dohm, president; O. H. Hallberg, vice-president; Robert L. Carter, secretary-treasurer; and E. L. Warner, director. The program was in charge of E. L. Warner, who introduced Claude C. Charley, a radio operator for the U. S. Coast Guard. Mr. Charley showed an interesting and informative sound motion picture entitled "The Story of the Coast Guard." On January 4 a special meeting of the Tacoma Section took place at the Tacoma Hotel, with 17 present. The entertainment on this occasion was again in charge of Mr. Warner, who had arranged for a talk by George M. Boyd, of the Westinghouse Corporation. Mr. Boyd's subject was "Principles of Illumination and Its Possibilities for the Future," which proved to be of great interest.

### Tennessee Valley Section

The regular monthly meeting of the Knoxville Subsection of the Tennessee Valley Section was held at the University of Tennessee cafeteria on January 7. The 50 members present at this session heard C. E. Blee give an interesting lecture on various hydroelectric projects in British Columbia with which he has been connected. Mr. Blee is now project engineer for the Tennessee Valley Authority.

## Student Chapter Notes

### Agricultural and Mechanical College of Texas

On November 24 the Agricultural and Mechanical College of Texas Student Chapter enjoyed the Society's lantern slide lecture on aerial photographic mapping. Recently the Chapter gave a dinner in honor of J. M. Howe, consulting engineer of Houston, Tex. Mr. Howe presented an interesting talk on the prospects of the young civil engineer.

### Case School of Applied Science

Early in December the Case School of Applied Science Student Chapter was honored by having as its guest Daniel W. Mead, President of the Society, who addressed the group informally. On December 17 members of the Chapter made an inspection trip to the Pleasant Hill and Mohicanville dams in the Muskingum Valley Conservancy District. This trip was made possible and arranged by J. M. Belknap, chief area engineer of the District.

### Tulane University

In October the Tulane University Student Chapter entertained Daniel W. Mead, President of the Society, who discussed the problems confronting the young engineer upon his graduation from college. Dr. Mead also spoke of his own experiences as a college professor and as a consulting engineer. He was introduced by J. F. Coleman, Past-President of the Society, and short addresses of welcome were also made by James M. Robert, dean of the college of engineering; Col. E. S. Bres, contracting engineer of New Orleans; and C. H. Stem, president and general manager of the New Orleans Equipment Company.

### University of Alabama

On November 16 the University of Alabama Student Chapter held a meeting for the purpose of showing the Society's lantern slides on Coolidge Dam. A short business session was also held, and plans were discussed for the annual engineers' day celebration to be held in March 1937.

### University of Michigan

At a meeting of the University of Michigan Student Chapter, held at the Michigan Union in Ann Arbor, on December 9, 1936, James H. Cissel, professor of structural engineering at the university and for the past three years engineer of bridge design for the Michigan State Highway Department, presented an interesting lecture on the economic and structural aspects of the San Francisco–Oakland Bay Bridge. The lecture was illustrated by slides, some of which were obtained from the Society, the rest being the property of Professor Cissel. There were 55 present.

# ITEMS OF INTEREST

*Engineering Events in Brief*

## Civil Engineering for March

An interesting group of over a dozen papers, together with a number of committee reports, is being presented at the Eighty-Fourth Annual Meeting of the Society, in progress at the time this issue of Civil Engineering goes to press. These papers cover such topics as highway planning surveys and improvements, water supply and sewage disposal, steel-pile pier and suspension-bridge construction, and various aspects of city planning.

Following the procedure initiated in connection with the Pittsburgh Meeting papers, certain addresses and reports will be abstracted in fairly complete form in Civil Engineering; the others will be given comparatively brief notice therein in anticipation that they may be published in full in Proceedings at a later date. The disposition of each will be determined through study by the Committee on Publications, and in both publications an effort will be made to convey to all members a full measure of the inspiration experienced by those attending the Annual Meeting.

## F. G. Cottrell Chosen to Receive Washington Award

Announcement is made by the Western Society of Civil Engineers that the Washington Award for 1937 will go to Frederick Gardner Cottrell, of Washington, D.C., who perfected the process by which the cost of helium gas was reduced from $1,700 to 10 cents a cubic foot, for his "social vision in dedicating to the perpetuation of research the rewards of his achievements in science and engineering." This award is made annually—providing the members of the Award Commission agree on a deserving candidate—as an honor conferred on a brother engineer by his fellows for accomplishments which preeminently promote the happiness, comfort, and well-being of humanity. Its tangible symbol is a bronze plaque mounted in marble. There have been several years when no award was made.

Dr. Cottrell, president of Research Associates, Inc., is widely known as a chemist and metallurgist, a former director of the U. S. Bureau of Mines and director of the fixed nitrogen laboratory, U. S. Department of Agriculture. Besides his achievements in the cheap production of helium, Dr. Cottrell is famous for his work in nitrogen fixation, for his processes of cleansing gases of dust and dirt by electrical precipitation, and for research in petroleum technology.

The Washington Award is administered by the Western Society of Engineers in cooperation with four other great engineering societies, which are the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. Seventeen men, elected for the purpose, compose the award commission.

Dr. Cottrell is the fourteenth noted American engineer to receive this coveted award since it was founded in 1915 by John W. Alvord of Chicago. Nine are present or past members of the Society. The complete list of recipients follows:

1919—Herbert C. Hoover, Hon. M. Am. Soc. C.E., for his preeminent services in behalf of the public welfare.

1922—Robert W. Hunt, M. Am. Soc. C.E., for his pioneer work in the development of the steel industry and for a life devoted to the advancement of the engineering profession.

1923—Arthur N. Talbot, Hon. M. Am. Soc. C.E., for his life work as student and teacher, investigator and writer, and for his enduring contribution to the science of engineering.

1925—Jonas Waldo Smith, Hon. M. Am. Soc. C.E., for the rare combination of vision, technical skill, administrative ability, and courageous leadership in engineering.

1926—John Watson Alvord, Hon. M. Am. Soc. C.E., for his pioneer work in developing the fundamental principles of public utility valuation and his marked contributions to sanitary science.

1927—Orville Wright, for fundamental scientific research and resultant successful airplane flight.

1928—Michael Idvorsky Pupin, for devotion to scientific research leading to inventions which have materially aided the development of long-distance telephony and radio broadcasting.

1929—Bion Joseph Arnold, M. Am. Soc. C.E., for pioneering work in the engineering and economics of electrical transportation.

1930—Mortimer E. Cooley, Hon. M. Am. Soc. C.E., for vision and constructive leadership in the education of the engineer.

1931—Ralph Modjeski, M. Am. Soc. C.E., for his contribution to transportation through superior skill and courage in bridge design and construction.

1932—William David Coolidge, for his scientific spirit and achievement in developing ductile tungsten and the modern X-ray tube.

1935—Ambrose Swasey, Hon. M. Am. Soc. C.E., for his distinguished contributions as a builder of instruments, institutions, and men.

1936—Charles Franklin Kettering, for his high achievements in guiding industrial research toward the greater comfort, happiness, and safety of mankind in the home and on the highway.

1937—Frederick Gardner Cottrell, for his social vision in dedicating to the perpetuation of research the rewards of his achievements in science and engineering.

## J. L. Savage Asked to Address British Civil Engineers

In recent years the Institution of Civil Engineers of Great Britain has extended an occasional invitation to distinguished engineers from abroad to deliver lectures on important projects with which they have been connected. This year the honor has been accorded to J. L. Savage, M. Am. Soc. C.E., in recognition of his work on Boulder Dam as chief designing engineer of the Bureau of Reclamation.

J. L. Savage, M. Am. Soc. C.E.

Mr. Savage will go to England early in the spring, as the guest of the Institution, and will deliver his address in London on April 15, 1937.

The guest speakers of the Institution have included many notable engineers. During the last session (1935-1936) the two selected were A. W. K. Billings, M. Am. Soc. C.E., of Toronto, and Charles Prosper Eugene Schneider, Hon. M. Am. Soc. C.E., of Paris.

## Wise and Otherwise

Some problems are more difficult to state in algebraic terms than to solve after such statement has been made. A problem of this type, originating at the University of Illinois, has been transmitted by V. K. Hendricks, M. Am. Soc. C.E.

A rope weighing 2 oz per ft hangs freely over a pulley. A weight is attached to one end, balanced by a monkey on the other. The combined ages of the monkey and its mother are 4 years, and the weight of the monkey is as many pounds as the mother is years old. The mother is twice as old as the monkey was when the mother was

half as old as the monkey will be when the monkey is three times as old as its mother was when she was three times as old as the monkey was. The weight of the rope and the weight is half as much again as the difference between the weight of the weight and the weight of the weight plus the weight of the monkey. What is the length of the rope? (Not more than three unknowns are necessary for solution, and of this number one may be eliminated through the relationship expressed in the last sentence of the problem.)

In January's problem two men, *A* and *B*, were walking across a railroad trestle. Twenty feet before reaching the center they heard a train whistling behind them. *A* ran towards the approaching train at top speed and cleared the trestle just in time, but *B*, who ran away from the train with equal speed, was killed one foot from the far end of the trestle. The train was moving 8 times as fast as the men could run. It was required to find the distance between the train and the end of the trestle when the men heard the whistle.

If $x$ represents the distance covered by *A* in running toward the train, and $y$ the distance *B* traveled in running away from the train, then $x + 20 = y - 20 + 1$. From this, $y - x = 39$ ft, the distance *B* traveled after the train had reached the end of the trestle. In this time the train traveled $8 \times 39$ or 312 ft; therefore the trestle was 313 ft long. The distance between the train and the near end of the trestle when the whistle was heard must then have been $8\left(\frac{313}{2} - 20\right)$, or 1,092 ft.

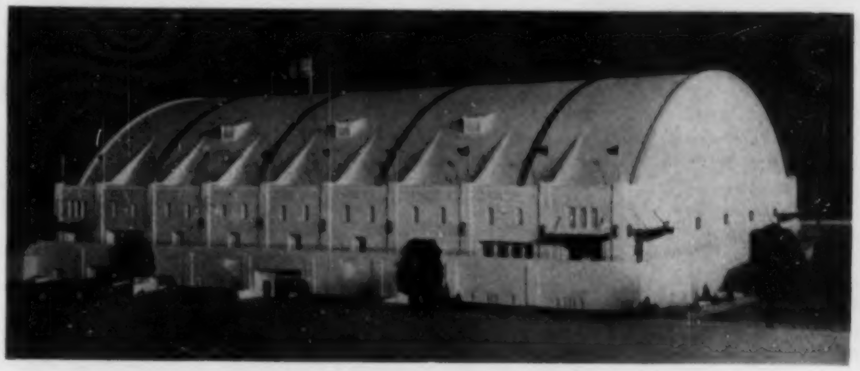
Suggestions for other problems for Professor Abercrombie's column, accompanied by solutions, may be addressed to the editor. Solutions should preferably be sent in separate enclosed envelopes.

## Iowa Engineering Society Sponsors Essay Contest

A STATE-WIDE essay contest, designed "to bring about a better understanding of the place of engineering in community life," is being sponsored in the high schools of Iowa by the Iowa Engineering Society. The subject, on which any high school senior may prepare a 1,000-word paper, is "What Engineering Has Done for My Community."

Several prizes are offered, including 15 cash awards totaling $90. In addition a medal is to be presented to the winner in each county, and a copy of "Vocational Guidance in Engineering Lines" will go to the school library of the successful contestant. The first and second prize essays are to be printed in the annual *Proceedings* of the Iowa Engineering Society.

The present contest is the first of a series to be conducted from year to year, and marks the adoption of an active "public relations policy," which the Iowa society hopes will bring the layman to understand the function of the engineer as well as he does that of the doctor and the lawyer.



A DISPLAY MODEL OF THE NEW HERSHEY SPORTS ARENA

## New Sports Arena Has Concrete Shell Roof

A CONCRETE shell roof supported on arch ribs of 232-ft span is the outstanding engineering feature of the new sports arena at Hershey, Pa. It is by far the largest roof of the type in the United States. The ribs are on 40-ft centers, and the slab between them is $3^{1}/_{2}$ in. thick. The roof was erected in 80-ft sections on a movable falsework structure containing 300,000 fbm of lumber and supported on 250 jacks.

The complete absence of interior supporting columns and truss work permits an unobstructed view of the entire arena from any seat in the building. Seating capacity, when the arena is used for such sports as hockey, is 7,100; when a smaller rink suffices, 10,000 persons can be accommodated. The building can be completely cleared of people in 60 seconds.

For acoustical reasons, the entire ceiling and all walls of the auditorium are lined with cork. This surface is painted a bluish white to produce an even distribution of indirect light. The main auditorium has no outside light, except for eight windows at one end.

Included in the equipment of the building is a refrigerating plant of 90-ton capacity. It will be used to manufacture ice for the surrounding community as well as for the hockey rink, and will have facilities for storing 35 carloads of vegetables.

This information and the accompanying photograph were sent by Alexander Stoddart, of Hershey Estates, Hershey, Pa.

## Standards Association Active in Many Fields

RECENT PROGRESS of the American Standards Association was sketched by its president, Dana D. Barnum, at the annual dinner meeting in New York on December 9.

During 1936, he said, "Industry and government have reached a high degree of cooperation in their numerous joint activities in the American Standards Association." He used as an illustration the forty industrial safety codes, now the backbone of state regulations for the protection of workers in this country. "These codes," he added, "have brought about a large degree of uniformity among the various states, not only to the benefit of employers, but to industrial and insurance groups as well."

During the year the association approved 33 new standards and 33 revisions. This brings the total number of American Standards to 357 in the fields of civil, mechanical, and electrical engineering, metallurgy, chemistry, textiles, oil, and paper, and other industries.

Marking virtual completion of a project started in 1927, new American Standards approved this year now classify coals from peat to anthracite. This undertaking, which will make possible the scientific purchase of coal, represents $100,000 in research spent by the United States and Canadian governments alone.

Three new standards in the field of sound measurement and nomenclature of sound will prove valuable to both engineers and musicians. One of these has resulted in a new "noise meter" to measure the sound of typewriter or pneumatic drill. Before this specification became available there were five meters on the market, the results of which were in no way comparable.

Increased attention to problems of traffic safety during the year has resulted in various new projects. Safety standards for buses and trucks, which were developed last winter at the request of the Interstate Commerce Commission, have since been used by that commission as a basis for public hearings.

Five national organizations have joined the association during the year, a striking indication of industry's confidence in the work. This brings the total membership of the American Standards Association to 56 national organizations, including technical societies (of which the American Society of Civil Engineers is one), trade associations, and departments of the federal government; and some 1,800 companies.

New undertakings are also under way in several other fields, including the formulation of a national building code, development of a series of codes for the prevention of occupational diseases such as silicosis, and specifications for consumer goods sold across the counter at retail.

At the business meeting following the dinner, Mr. Barnum was reelected presi-

dent, and Edmond A. Prentis, M. Am. Soc. C.E., was reelected vice-president.

A sectional committee to consider standard building code requirements for iron and steel, and to establish suitable working stresses for these materials, was authorized. The American Institute of Steel Construction and the American Society of Civil Engineers were invited to act together to take administrative responsibility for the committee. The Society has accepted this invitation and has appointed H. G. Balcom, M. Am. Soc. C.E., as its representative on the committee. Announcement was also made of the appointment of an advisory committee of experts to cooperate with this and other sectional committees by giving authoritative information on working stresses of building materials in general. It consists of F. E. Schmitt, chairman; Theodore Crane, Henry D. Dewell, Almon H. Fuller, Clifford M. Stegner, Clarence H. Sutherland, Watson Vredenburgh, Wilbur J. Watson, Herbert L. Whittemore, Wilbur M. Wilson, and Morton O. Withey. With the exception of Messrs. Whittemore and Withey, all are members of the Society.

## Brief Notes from Here and There

TWENTY-FIVE years of engineering research and advanced instruction will be celebrated by the Johns Hopkins School of Engineering in a program extending over February 19, 20, and 22. The anniversary events will include a varied exhibit of engineering materials and devices and a period of technical sessions. Prominent among the displays of current research projects will be a section devoted to recent developments in the field of civil engineering. The entire hydraulics laboratory is to be in operation, and models of sanitary engineering equipment may be examined. Of particular interest also will be the model of a new type of deep bridge foundation supported by tubular steel piles. A method for determining actual stresses and deflections by means of tests on this model will be demonstrated. Examples of the most recent progress in aerial photography for use in topographic surveying will also be on display. During the technical sessions each of the leading members of the faculty will read a paper covering a particular phase of research in his field. In attendance will be officials of the city and state and many engineers from other colleges and from industry.

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A FOUNDATION dedicated to research for benefit of the arc welding industry has recently been established by vote of the directors of the Lincoln Electric Company, of Cleveland, Ohio. The fund has been named "The James F. Lincoln Arc Welding Foundation," in honor of the pioneer work of the company's president in promoting arc welding and in developing equipment for use in that field. Dr. E. E. Dreese of Ohio State University will be in principal charge of the work.

## NEWS OF ENGINEERS

*Personal Items About Society Members*

C. B. BRYANT is now engineer of tests for the Southern Railway System at Alexandria, Va. Previously he was materials engineer for the Maryland State Roads Commission at Baltimore, Md.

WILLARD T. CHEVALIER, vice-president of the McGraw-Hill Publishing Company, and president of the American Road Builders' Association, has been appointed by the Secretary of State as a representative of the United States on the Permanent International Commission of the Permanent International Association of Road Congresses.

T. R. AGG, dean of engineering at Iowa State College, was given the George H. Bartlett award for achievement in highway work at a recent meeting of the Highway Research Board. This award, which is given by the American Association of State Highway Officials, the American Road Builders' Association, and the Highway Research Board, was presented to Dean Agg for his research work in highway engineering and economics for the Iowa Engineering Experiment Station.

WILLIAM BOWIE, chief of the division of geodesy of the U. S. Coast and Geodetic Survey, recently retired after more than forty-one years of service. Major Bowie entered the employ of the Survey in 1895 as a field engineer. Three years ago he was named president of the International Geodetic and Geophysical Union, being the first American to hold this position.

THOMAS M. RIDDICK, formerly associated with the late Nicholas S. Hill, Jr., as chemist and bacteriologist, has recently established a practice as consulting chemist at 369 East 149th Street in New York City, where he will specialize in water purification, sewage treatment, and allied fields.

LOUIS C. HILL is a member of the consulting board of three engineers which has been studying water supplies in southern California, with special reference to the possibility of use by San Diego of Colorado River water.

NORMAN M. HERTHE has withdrawn as a member of the firm of Ellsworth Barrows and Company and will continue his appraisal and survey practice, with offices at 110 Franklin Street, Buffalo, N.Y.

FRANCIS W. DANIELS, who has been connected with the H. K. Ferguson Company, of Cleveland, Ohio, since 1924, was recently appointed chief engineer in charge of engineering on all their projects.

KENNETH F. VERNON, an assistant engineer in the U. S. Bureau of Reclamation, has been transferred from Denver, Colo., to the Central Valley project in California, where he has been assigned to the Contra Costa canal work.

JAMES H. HERRON, a consulting engineer of Cleveland, Ohio, has been installed as president of the American Society of Mechanical Engineers for 1937. As a member of that society, he served on the committee on its local sections from 1917 to 1922, and was a member of the A.S.M.E. Council

JAMES H. HERRON

from 1922 to 1925. In 1934 he was elected vice-president of the society. Since 1909 Mr. Herron has been president of the James H. Herron Company, engineers and chemists. He has been a member of the American Society of Civil Engineers since 1926.

SAMUEL KOFFSKY recently resigned as assistant supervisor of operations for District 2 of the New York State WPA to become consulting engineer to the Simmons Machine Tool Corporation, in Albany, N.Y. His work will include the intensive development of a seven-acre industrial tract adjacent to the Simmons shops.

ALEX DOW, president of the Detroit Edison Company, has been awarded the American Institute of Electrical Engineers' Edison Medal for 1936 "for outstanding leadership in the development of the central station industry and its service to the public." The medal, which was founded by friends and associates of the late Thomas A. Edison, was presented to Dr. Dow during the winter convention of the Institute.

WALTER B. ANTHONY, formerly resident engineer for the U. S. Corps of Engineers at Winona Dam on the Mississippi River, has been transferred to the first New York district, where he is now in charge of the cost-estimating department.

HARRY A. HAGEMAN has been appointed chief hydraulic designing engineer of the Tennessee Valley Authority, with headquarters at Knoxville, Tenn. He was previously public buildings commissioner of Newton, Mass.

JOHN W. WHEELER, a member of the Indiana State Highway Commission, recently became engineer of highway negotiations for the Burlington Railroad. Working under the executive vice-president in charge of operations, he will handle the grade-crossing program in the states served by the railroad.

Norman J. Castellan, formerly in the design department of the U. S. Bureau of Reclamation in Denver, is now an instructor in the Colorado School of Mines.

Lewis V. Carpenter has been promoted from the position of associate professor of sanitary engineering at New York University to that of professor.

## DECEASED

Le Roy Wright Barbour (Assoc. M. '20), superintendent of the Gladewater and Fort Worth refineries of the Sinclair Refining Company, Fort Worth, Tex., died on September 14, 1936. Mr. Barbour was born at Greenwich, N.Y., on October 22, 1882, and graduated from Stanford University in 1909. His early career included experience as resident engineer on the construction of various dams and reservoirs in California and as resident engineer for Gainesville, Tex., and Cushing, Okla. From 1922 to 1927 he was superintendent of the Pierce Refinery at Tampico, Mexico, and from the latter year until 1930 he was manager of refineries, pipe lines, and production for this company at Tulsa, Okla. In 1931 he became superintendent of the Gladewater and Fort Worth refineries.

Thurston Carlyle Culyer (M. '13), a real estate appraiser for Pease and Elliman, Inc., of New York City, died at his home in Astoria, L.I., on December 9, 1936, at the age of 70. Mr. Culyer was born in New York City and educated at Brooklyn Polytechnic Institute. In 1884, after brief experience in engineering work in Boston, he entered the New York City Department of Public Works, where he remained for many years. In 1892 he was made engineer in charge of surveys for reservoir lands, and in 1910 he became assistant engineer in charge of all work for the Department in the Croton, Byram, and Bronx watersheds. Recently Mr. Culyer became connected with Pease and Elliman, Inc.

Harry Jocelyn Dignum (M.'22 ), of Kingston, Jamaica, died on December 26, 1936, at the age of 57. Mr. Dignum was born at Falmouth, Jamaica, and graduated from Jamaica College in 1901. From 1903 to 1905 he was with the Jamaica Government Railway, and from 1905 to 1908 was with the Isthmian Canal Commission. From 1910 to 1913 he was with the Nipe Bay Company, of Cuba, and from 1915 to 1917 was superintendent of bridge construction for the United Fruit Company in Spanish Honduras. Beginning in 1918, he was for a number of years superintendent of railroads and transportation for the Baragua Sugar Company, of Cuba. From 1931 until shortly before his death Mr. Dignum was in the surveyor general's office in Kingston.

Howard Lewis Francis (Assoc. M. '13) died at San Antonio, Tex., on December 11, 1936. Mr. Francis was born at Charlevoix, Mich., on November 27, 1884, and graduated from Michigan State College in 1906. From 1909 to 1912 he was superintendent of bridges and buildings for the Mexican Tramways Company and the Mexican Light and Power Company. From 1912 to 1914 he served as district engineer of the Uruguay Railway Company in South America, and from 1915 to 1920 he was chief engineer of the Dominican Central Railroad in the Dominican Republic. In 1921 Mr. Francis became vice-president and general manager of the American Sanitary Company in Mexico City, where he remained until 1928.

Abraham Gideon (M. '10), consulting engineer of Oakland, Calif., died at his home in that city on December 17, 1936, at the age of 65. Mr. Gideon was born in Toula, Russia, and graduated from Cornell University in 1895. In 1900, after early engineering experience in this country, he was appointed assistant engineer of the city of Havana, Cuba, where for the next ten years he was in active charge of various sewer and water projects, including the construction of a new sewerage system. He then became chief of the department of sewer and water-works construction for Manila, P.I. Later he was made managing director of the Metropolitan Water District of the same city. In 1931 Mr. Gideon returned to the United States and established his practice in Oakland.

*The Society welcomes additional biographical material to supplement these brief notes and to be available for use in the official memoirs for "Transactions."*

John Herbert Gregory (M. '06), consulting engineer and professor of civil and sanitary engineering at Johns Hopkins University, Baltimore, Md., died on January 18, 1937, as a result of a cerebral hemorrhage. He was born in Cambridge, Mass., on August 7, 1874, and graduated from the Massachusetts Institute of Technology in 1895. From then on Professor Gregory was actively engaged in the design and construction of sanitary engineering works in various cities in this country and Canada. From 1911 to 1917 he was a member of the firm of Rudolph Hering and John H. Gregory, consulting engineers of New York, and after 1919, in addition to his consulting practice, he was a member of the faculty of Johns Hopkins University. In 1932 he was appointed a member of the Engineers' Advisory Board of the Reconstruction Finance Corporation. In 1910 Professor Gregory was awarded the Thomas Fitch Rowland Prize of the Society; in 1930, in conjunction with others, the James Laurie Prize; and in 1936, with others, the Rudolph Hering Medal. He was a Director of the Society from 1932 to 1934, a member of its Committee on Publications in 1933 and 1934, and chairman of the Committee in 1934.

John Herbert Gregory

Charles Hansel (M. '94), consulting engineer of Cranford, N.J., died at his winter home at Punta Corda, Fla., on December 24, 1936. Mr. Hansel, who was 77, was born in Peoria, Ill. From 1884 to 1889 he was chief engineer of the Wabash Railroad and later became first consulting engineer for the Illinois Railroad and Warehouse Commission. From 1904 to 1906 he served as consulting engineer to the Indiana Harbor Railroad Company and later was in charge of the valuation of railroads and canals in New Jersey. From 1913 on he was a member of the President's Conference on the Engineering Committee of Railroads and was chairman of the valuation committees of several railroads. Until recently Mr. Hansel was active in the firm of Charles Hansel Construction Specialists, with offices in Washington, D.C., and for the past ten years he was president of the Union County (N.J.) Park Commission.

Robert Sharp Jones (Assoc. M. '10), of Cleveland, Ohio, died on June 5, 1936. Mr. Jones was born at Dover, Mass., on October 14, 1875, and graduated from Massachusetts State College in 1895. From 1905 to 1909 he was contractor's chief engineer for various water filtration plants in Cleveland and later served as resident construction engineer for the Cleveland West Side Filtration Plant. From 1919 to 1925 Mr. Jones was a partner in the Rice-Jones Company, general contractors, of Cleveland. In the latter year he became chief engineer of the Stange Construction Company, where he remained until 1930. From 1931 to 1933 he was resident construction engineer for the Cleveland Easterly Sewage Treatment Works.

Olaf Ingvald Knoph (M. '19), a consulting engineer of Berlin, Germany, died on November 22, 1936. Mr. Knoph was born in Trondhjem, Norway, on September 22, 1876, and graduated from the Technical College of Trondhjem in 1895. From the latter year until 1902 he was employed on fortification works in Norway. From 1903 to 1907 he was chief draftsman for the London and Fulham Steel Works in London and later served as chief steel and concrete designer for a hydroelectric company in Norway. From 1912 to 1924 Mr. Knoph maintained a consulting practice in Oslo, Norway. In

the latter year he established a practice in Berlin.

JAMES SAMUEL MCALLISTER (Jun. '34), in the employ of the Mason-Walsh-Atkinson-Kier Company, was accidentally killed on the job at Grand Coulee Dam on May 23, 1936, while acting in the capacity of concrete foreman. Mr. McAllister was born in Portland, Ore., on March 15, 1907, and graduated from Oregon State College in 1934. Prior to his graduation, he was in the employ of the U. S. Bureau of Public Roads for a year, and in 1934 he became an inspector for the Mason-Walsh-Atkinson-Kier Company at Bonneville Dam. Later he was made a foreman on the construction of Grand Coulee Dam.

DAVID CHARLES SERBER (M. '09), a civil engineer and contractor of New York City, died there on December 16, 1936, at the age of 68. Mr. Serber, who was a native of Russia, was educated at the University of Kiev and Columbia University. From 1896 to 1903 he was in the New York City Department of Public Works, and from 1903 to 1908 was structural engineer for Henry Steers, Inc., on river and harbor work. In 1912 he organized his own company, D. C. Serber, Inc., specializing in subway contracts. This company built part of the 207th Street extension of the Eighth Avenue subway and stations in New York and Brooklyn for the Brooklyn Manhattan Transit system. Mr. Serber developed the vertical I-beam system of bracing deep excavations and was the author of *The Analysis of the Design of Retaining Structures*.

CLIFFORD JUSTI THIEBAUD (Assoc. M. '23), chief engineer of the Capitol Steel and Iron Company, Oklahoma City, Okla., since 1931, died on November 8, 1936. Mr. Thiebaud was born at Vevay, Ind., on March 23, 1889, and graduated from Purdue University in 1913. His early experience was in the U. S. Engineer Department, and during the war he was first lieutenant and, later, captain in the Engineers Corps of the U. S. Army. From 1921 to 1924 Mr. Thiebaud was superintendent on the construction of various refineries for the Sinclair Oil Company, and from 1925 to 1928 he was in charge of the engineering department of the J. B. Klein Iron and Foundry Company. In the latter year he became manager and vice-president of the Western Steel and Erection Company, where he remained until 1931.

SAMUEL C. WEISKOPF (M. '88), former consulting engineer of New York City, died at his home in St. Petersburg, Fla., on December 20, 1936, at the age of 76. Following his graduation from the University of Michigan in 1882, Mr. Weiskopf entered the employ of the Chicago, Milwaukee and St. Paul Railroad and, later, of the Carnegie Steel Company. In 1895 he opened his own office in New York City, where he played a prominent part in the development of the skyscraper. He was responsible for the design of many of the city's large structures, including the American Radiator Building and the American Telephone and Telegraph Building. In 1925 Mr. Weiskopf was called to Japan to advise on the construction of earthquake-proof structures. Upon retiring six years ago, he became a resident of St. Petersburg, Fla.

JAMES CUMMIN STEVENSON (M. '19), a consulting engineer of Chicago, Ill., died in Winnetka, Ill., on December 29, 1936. Mr. Stevenson, who was 51, graduated from the University of Texas in 1908. In 1909 and 1910 he was assistant city engineer of Galveston, Tex., and in 1911 he became topographer in charge of a party for the U. S. Boundary Commission. From December 1911 until 1935 he was with H. S. Stevens and Company, of Chicago—first as assistant engineer, later as general superintendent of construction, and finally as vice-president. This company specialized in the design and construction of hotels. During the war Mr. Stevenson was in charge of construction at the Brooklyn Navy Yard.

CHARLES VICTOR WITT (M. '27) died at Greensburg, Pa., on December 6, 1936, at the age of 58. A native of Germany, Mr. Witt graduated from the University of Dresden in 1900 and came to the United States in 1901. After a year with the Carnegie Steel Company, he was employed as a mechanical engineer by the Westinghouse Electric and Manufacturing Company, until 1906. For the next 26 years he was with the James McNeil and Brothers Company, first as general manager and later as vice-president and director. From 1926 to 1932 Mr. Witt served as president of the Witt Steel Company, of Greensburg, and from the latter year until his retirement in 1935 he was chief engineer and general manager of the Steel Watermains Association of the same city.

# Changes in Membership Grades

*Additions, Transfers, Reinstatements, and Resignations*

**From December 10, 1936, to January 9, 1937, Inclusive**

## ADDITIONS TO MEMBERSHIP

ALPER, ALBERT (Jun. '36), 707 Eastgate, St. Louis, Mo.

ARNE, I. CHRISTIAN (Jun. '36), Junior Highway Engr., State Div. of Highways (Res., 2908 West North Ave.), Chicago, Ill.

AUSTIN, ROBERT DALE (Jun. '36), Route 1, Ceres, Calif.

BARR, ALBERT STEPHEN, JR. (Jun. '36), 261 Emerson St., Pittsburgh, Pa.

BARTUS, JULIUS FRANCIS (Jun. '36), Batch Plant Insp., Gen. Motors Proving Ground, Milford, Mich.

BAYLES, CHARLES CLIFFORD (Jun. '36), Care, State Highway Office, McMinnville, Ore.

BELSTERLING, RICHARD GORDON (Jun. '36), 3934 Prospect Rd., Peoria Heights, Ill.

BERGESON, JOHN TRUE (Jun. '36), 55 Church St., Charleston, S.C.

BERKEM, MUHITTIN KASIF (Jun. '36), Superv. Engr., S. Durusan, Burdur (Res., 155 Gazi Caddesi, Samsun), Turkey.

BOCCIO, JOSEPH MICHAEL (Jun. '36), Asst. to A. Boccio, 146-12 Delaware Ave., Flushing, N.Y.

BORCHELT, THOMAS CHARLES (Jun. '36), Care, Standard Brands, Inc., Pekin, Ill.

| TOTAL MEMBERSHIP AS OF JANUARY 9, 1937 | |
|---|---|
| Members | 5,642 |
| Associate Members | 6,004 |
| Corporate Members | 11,646 |
| Honorary Members | 24 |
| Juniors | 3,357 |
| Affiliates | 87 |
| Fellows | 1 |
| Total | 15,115 |

BOUCHER, FRANCIS LE ROY (Jun. '36), Millington, N.J.

BRANDOW, GEORGE EVERETT (Jun. '36), Junior Structural Engr., W. E. Wilson (Res., 144 West 59th St.), Los Angeles, Calif.

CARSON, ALBERT CASSON (Jun. '36), 8 Purple St., Wellsboro, Pa.

CERVANTES, JOSÉ MALO (Jun. '36), 512 South 5th St., Columbia, Mo.

CLARK, LEON HERBERT (Jun. '36), 98 South Manor Ave., Kingston, N.Y.

COOPER, HAROLD HOWARD (Jun. '36), Bridge Draftsman, State Highway Dept. (Res., 604 Washington Apartments), Lansing, Mich.

COPELAND, WILLIAM EDWARD (Jun. '36), Road Draftsman, State Highway Dept., Y.M.C.A., Columbia, S.C.

CRONKRIGHT, ARTHUR BRADFORD (Jun. '36), 154 Magnolia Ave., Arlington, N.J.

CURL, STODDARD WHINFIELD (Jun. '36), Junior Eng. Draftsman, TVA, Pound Bldg., 641 Battery Pl., Chattanooga, Tenn.

Deegan, Edward Joseph (Jun. '36), 1027 Lake Michigan Drive, Grand Rapids, Mich.

Demarest, Richard Terhune (Jun. '36), Senior Technician, Plumbing Survey, U. S. Public Health Dept. and WPA (Res., 254 Seaman Ave.), New York, N.Y.

Douglass, Wilford Franklin (Jun. '36), Acting Supt. of Constr., Tri-City Airport, WPA, Box 208, Bristol, Tenn.

Eitelberg, Sidney (Jun. '36), Clerk, Sears Roebuck & Co., 360 West 31st St., New York (Res., 104 Heyward St., Brooklyn), N.Y.

Elsenhans, George Edward (Jun. '36), 128 North 26th St., Camp Hill, Pa.

Evans, John Joseph (Jun. '36), 101 Paine St., Worcester, Mass.

Flay, George Francis, Jr. (Jun. '36), Job Engr., Spencer, White & Prentis, Inc., 10 East 40th St., New York (Res., 2434 Thirty-Fifth St., Astoria), N.Y.

Fogle, James Gerald (Jun. '36), Salmo, B.C., Canada.

Galpin, Edward Glann (Jun. '36), With Bethlehem Steel Co., Erection Dept., Manchester, N.H.

Gerfen, William Howard (Jun. '36), 210 North McPherrin, Monterey Park, Calif.

Gilman, Roger Howe (Jun. '36), 1734 Cambridge St., Cambridge, Mass.

Gitter, Lester Jonas (Jun. '36), 1005 Lincoln Pl., Brooklyn, N.Y.

Glasser, Arthur Frederick (Jun. '36), Estimator and Engr., Dravo Contr. Co., 530 Academy Ave., Sewickley, Pa.

Gould, Robert Sewall (Jun. '36), Junior Topographic Engr., U. S. Geological Survey, Box 346, Sacramento, Calif.

Hale, Kenneth (Jun. '36), 2162 La Fontaine Ave., New York, N.Y.

Hamilton, William Clifford (Jun. '36), 1042 Peralta St., Berkeley, Calif.

Holliday, Alan Washburn (Jun. '36), 315 South 12th St., Laramie, Wyo.

Irvine, John McIlrath (Assoc. M. '36), Res. Engr. and Asst. to Pres., Albright & Friel, Inc., 1520 Locust St. (Res. 21 East Penn St., Germantown), Philadelphia, Pa.

Jacoby, Hurlbut Saylor (Jun. '36), Salesman, Standard San. Mfg. Co. (Res., 51 Avon Pl.), Springfield, Mass.

Johnson, Emory Emmanuel (Jun. '36), 612 South 16th St., Lincoln, Nebr.

Johnson, Wayne Frost (Jun. '36), Urich, Mo.

Judah, Courtney Thomas (Assoc. M. '36), Asst. Dist. Engr., U. S. Dept. of Agriculture, SCS, Vacaville, Calif.

Kamalsky, Thomas Karl (Jun. '36), 671 Grant St., Watertown, N.Y.

Kehoe, Edward James (Jun. '36), 298 Thirteenth St., Brooklyn, N.Y.

Kennedy, Charles Thomas (M. '36), Cons. Engr., 2104 Madison Rd., Cincinnati, Ohio.

Keosaian, Edward (Jun. '36), Rodman, with Boro Pres. of Manhattan, Boro and Street Survey (Res., 667 East 165th St.), New York, N.Y.

Kestner, Joseph Aloysius, Jr. (Jun. '36), With Burr M. Stark, Troy (Res., 204 Elmer Ave., Schenectady), N.Y.

Keyes, Francis Holmes (Jun. '36), General Delivery, Kendrick, Idaho.

Kiebel, Charles Bernhard, Jr. (Jun. '36), 18 Highland Terrace, Manhasset, N.Y.

King, Karl Kenneth (Jun. '36), 214 Crawford Ave., Effingham, Ill.

Langbein, Leland Henry (Jun. '36), Civ. Engr. Draftsman, Gibbs & Hill, Pennsylvania Station, New York, N.Y. (Res., Lincoln Highway, Franklin Park, N.J.).

Levine, Lewis (Assoc. M. '36), Superv. Engr., Div. of Design, WPA, 70 Columbus Ave., New York (Res., 3822 Atlantic Ave., Seagate, Brooklyn), N.Y.

Levy, Marcus Westerfeld (Jun. '36), 949 Hyde Park Boulevard, Chicago, Ill.

Lewis, Wayne Cuthbert (Jun. '36), Senior Eng. Aid, Div. 1, State Highway Comm. (Res. 2312 Upham St.), Madison, Wis.

Lindstrom, William August (Jun. '36), 332 East 38th St., New York, N.Y.

Loewenthal, Julius (Jun. '36), 313 East 4th St., New York, N.Y.

McKesson, Eldred Kenney (Jun. '36), 2163 Mountain View Ave., San Bernardino, Calif.

McKinley, Henry (Jun. '36), 549 North Beville Ave., Indianapolis, Ind.

Mabin, Thomas Herbert (Jun. '36), 66 1/2 Sixth Ave., Troy, N.Y.

Maiale, Anthony Joseph (Jun. '36), 836 Bush St., Bridgeport, Pa.

Maloney, Pirie Joseph (Jun. '36), Care, William H. Hintelmann, Ridge Rd., Rumson, N.J.

Marshall, David McLaren (Jun. '36), 7 Princeton St., Nutley, N.J.

Martin, Paul Gordon (Assoc. M. '36), Asst. Office Bridge Engr., State Highway Comm., Topeka, Kans.

Martinson, Norman Louis (Jun. '36), Topographer, U. S. Bureau of Reclamation, Box 325, Tucumcari, N.Mex.

Mecredy, Henry Edwards (M. '36), Dist. Director, Dist. II-W, WPA of Virginia, 319 Second St., S.W., Roanoke, Va.

Meranda, Norman Eugene (Jun. '36), Jackson Center, Ohio.

Millen, Vincent Laddie (Jun. '36), Junior Salesman, Jones & Laughlin Steel Corporation, Box 315, Jacksonville, Fla.

Miller, Everett (Jun. '36), 13 Emerson Pl., Newark, N.J.

Morin, John Abner (Jun. '36), Insp., Joint Highway Dist. 13, 14th and Webster Sts., Oakland (Res., 2325 Edwards St., Berkeley), Calif.

Morrill, Laren D. (Jun. '36), Y.M.C.A. Bldg., Room 414, Denver, Colo.

Mortimer, Winfield Stout (Jun. '36), 2131 West College, Spokane, Wash.

Newman, Joseph John (Jun. '36), Junior Eng. Aid, TVA, Hydr. Laboratory, Norris, Tenn.

Nutter, Ben Earl (Jun. '36), 736 Parkman Ave., Los Angeles, Calif.

Orr, Joseph Anderson (Assoc. M. '36), Associate Prof., Civ. Eng., Agri. and Mech. Coll. of Texas, Box 145, Faculty Exchange, College Station, Tex.

Page, John Chatfield (M. '36), Acting Commr., U. S. Bureau of Reclamation (Res., 6600 Barnaby St., N.W.), Washington, D.C.

Peller, Phillip Allen (Jun. '36), 615 South 14th Ave., Maywood, Ill.

Piazza, Sal Joseph (Jun. '36), 1449 Olmstead Ave., New York, N.Y.

Pope, Thomas Flint (Jun. '36), Junior Highway Engr., State Highway Dept., 1108 South 2d St., Springfield, Ill.

Pracy, George Wesley, Jr. (Jun. '36), Box 97, Avenal, Calif.

Prange, Robert Louis (Jun. '36), Draftsman, Ramapo Ajax, 4287 Holly Ave., St. Louis, Mo.

Prince, Clyde Duane (Jun. '36), Chainman, N.Y.C.R.R., 466 Lexington Ave. (Res., 243 Bedford Park Boulevard), New York, N.Y.

Reichmann, Albert Ferdinand, Jr. (Jun. '36), 515 South Lehigh Ave., Frackville, Pa.

Reynolds, John Thomas (Jun. '36), Draftsman, Black & Veatch, Kansas City (Res., 503 South Main St., Independence), Mo.

Rihm, Alexander, Jr. (Jun. '36), 114-19 One Hundred and Twentieth St., South Ozone Park, N.Y.

River, Robert Beaudon (Jun. '36), Junior Highway Engr., Dist. IV, State Div. of Highways, State Bldg. (Res., 221 Seventh Ave.), San Francisco, Calif.

Rogers, Donald Frederick (Jun. '36), 40 Robin St., Rochester, N.Y.

Ruth, Joseph Francis (Jun. '36), 3824 Waldo Ave., New York, N.Y.

Ryan, George Aloysius (Jun. '36), 259 Carlton Ave., Brooklyn, N.Y.

Schaaf, Robert Rudolph (Jun. '36), 456 Twin Oaks Rd., Union, N.J.

Schoell, William Davenport (Jun. '36), 126 East Frazee St., Detroit Lakes, Minn.

Shriver, Karl Henry (M. '36), Associate Engr., U. S. Engr. Dept. (Res., 78 Mayfair Drive, Mount Lebanon), Pittsburgh, Pa.

Shultz, Maurice Leonard (Jun. '36), U. S. Engr. Office, New Hampton, N.Y.

Simons, Edward Gordon (Jun. '36), 7112 Stewart Ave., Chicago, Ill.

Smith, Adrian Woodrow (Jun. '36), 674 Sixth Ave., Salt Lake City, Utah.

Smith, Walter Lane (Jun. '36), Pres., Memphis Stone & Gravel Co., 1828 Exchange Bldg., Memphis, Tenn.

Sparrow, George Bradley (Jun. '36), 905 Cooper St., Camden, N.J.

Squires, Franklin Wardwell (Jun. '36), Eng. Apprentice, P.R.R., M. of W. Dept., Philadelphia (Res., 25 Elliott Ave., Bryn Mawr), Pa.

Starke, William Wallace, Jr. (Jun. '36), Care, Lt. J. M. Duke, U. S. Naval Air Station, Pensacola, Fla.

Stewart, George Moriarty (Jun. '36), 710 West Roma, Albuquerque, N.Mex.

Straub, Conrad Paul (Jun. '36), 730 Grove St., Irvington, N.J.

Sutphin, Bertram Harrison, Jr. (Jun. '36), 275 Ocean Ave., Brooklyn, N.Y.

Thoren, Clarence Christ (Jun. '36), 1104 North Lima St., Burbank, Calif.

Thoroughman, Frank Marion Mathewson (Jun. '36), Student Engr., U. S. Engr. Office, Alton, Ill. (Res., 3731 Olive St., St. Louis, Mo.).

Van Wert, Franklin Stevens (Jun. '36), 246 Oakland Ave., Pittsburgh, Pa.

Volz, Lawrence Henry (Jun. '36), Office of Div. Engr., C. M. St. P. & P. Ry., Butte, Mont.

Walker, Ray Lester (Jun. '36), 2865 Santa Clara Ave., Alameda, Calif.

Warren, Frederick Hayes (Jun. '36), Chf. Examiner, Self Liquidating Div., RFC (Res., 3106 Thirty-Fourth St., N. W.), Washington, D.C.

Weinberg, David (Jun. '36), 730 North Main St., Sheridan, Wyo.

Wilkinson, Conrad Hopp (Jun. '36), U. S. Engr. Office, Security Mutual Bldg., Binghamton, N.Y.

Winey, Arthur Henry (Jun. '36), With White Constr. Co. (Res., 60 Annetta Ave.), Northport, N.Y.

Wright, Wells Dungan (M. '36), Chf. Insp., Section of Office Engr., The Panama Canal, Box 114, Balboa Heights, Canal Zone.

Wu, Hang-Mien (Jun. '36), 407 South Capitol St., Iowa City, Iowa.

Yanchewski, Ludwig Adam (Jun. '36), 737 East 219th St., New York, N.Y.

Young, Campbell Austin (Assoc. M. '36), With Sheffield Steel Corporation (Res., 229 Ward Parkway), Kansas City, Mo.

### Membership Transfers

Allison, William Henry (Assoc. M. '29; M. '36), Asst. Prof., Civ. Eng., Clarkson Coll. of Technology (Res., 20 Leroy St.), Potsdam, N.Y.

Archibald, Raymond (Assoc. M. '31; M. '36), Constr. Engr., U. S. Bureau of Public Roads, Apartado IX, San José, Costa Rica.

Back, Nicholas Valentine (Jun. '27; Assoc. M. '36), Designer, N.Y.C.R.R., 466 Lexington Ave., New York, N.Y. (Res., 917 West Girard Ave., Philadelphia, Pa.).

Barnes, Donald Porter (Jun. '30; Assoc. M. '36), Associate Engr., U. S. Bureau of Reclamation (Res., 2557 Ash St.), Denver, Colo.

Beermann, Paul (Jun. '27; Assoc. M. '36), Engr., Div. of Development and Conservation, Water Dept., City of San Diego, 524 F St. (Res., 3904 Orange Ave.), San Diego, Calif.

Benson, Mons Herman (Jun. '30; Assoc. M. '36), Asst. Structural Engr., TVA, 711 Union Bldg., Knoxville, Tenn.

Bowman, Frederic Berkeley (Jun. '34; Assoc. M. '36), Asst. Engr., Canals Div., U. S. Bureau of Reclamation, Customs House (Res., 1957 South Corona St.), Denver, Colo.

Cotter, Albert Adiel (Assoc. M. '08; M. '36), Head of Mech. Equipment and Top-Works Div., Project Dept., Kuzbasshaftstroy, Novosibersk, Siberia, Union of Socialistic Soviet Republics.

Galt, Charles Elijah (Assoc. M. '17; M. '36), Pres., Atlas Iron Works, St. Louis, Mo.

Garnett, Ernest Edwin, Jr. (Jun. '27; Assoc. M. '36), Civ. Eng. Insp., San Francisco Water Dept., 425 Mason St. (Res., 1200 Sacramento St., Apartment 402), San Francisco, Calif.

Guerdrum, George Hagbart (Assoc. M. '16; M. '36), Civ. Engr. (Geo. H. Guerdrum & Sons), 1317 Willow St., San Antonio, Tex.

Hedefine, Alfred (Jun. '31; Assoc. M. '36), Designer and Detailer, Waddell & Hardesty, 142 Maiden Lane, New York, N.Y. (Res., 121 Tappan St., Kearny, N.J.).

Hook, Addison Eastwick (Jun. '29; Assoc. M. '36), Associate Office Engr., TVA (Res., 1021 Circle Park), Knoxville, Tenn.

Hull, William Janney (Jun. '31; Assoc. M. '36), Engr., Board of Water Supply, Honolulu, Hawaii.

Jakkula, Arne Arthur (Jun. '28; Assoc. M. '36), Asst. Prof., Civ. Eng., Univ. of Michigan, Ann Arbor, Mich.

Kilcarr, Gilbert Michael (Assoc. M. '21; M. '36), Vice-Pres., Interstate Equipment Corporation, 18 West Jersey St., Elizabeth, N.J.

Kirby, Herman Estel (Jun. '26; Assoc. M. '36), Asst. Cost Engr., C. & O. Ry. (Res., 3203 First Ave.), Richmond, Va.

Large, Joseph G. (Jun. '26; Assoc. M. '36), Structural Draftsman, Isaacson Iron Works (Res., 1620 Fourteenth Ave.), Seattle, Wash.

Laskowski, John (Jun. '27; Assoc. M. '36), Junior Hydrographic and Geodetic Engr., U. S. Coast and Geodetic Survey, Washington, D.C.

McCord, Herbert Weymouth (Jun. '28; Assoc. M. '36), Asst. Supt., Post & McCord, Inc., Erection Dept., 101 Park Ave., New York, N.Y.

Odessey, Herman Paul (Jun. '22; Assoc. M. '28; M. '36), Commanding Officer, U. S. Coast and Geodetic Survey, Washington, D.C. (Res., 1019 Jamestown Crescent, Norfolk, Va.).

Pitcher, Franklin (Jun. '26; Assoc. M. '36), Asst. Examiner, TVA, Personnel Div., Fountain City Branch, Knoxville, Tenn.

Salter, George Stauffer (Jun. '23; Assoc. M. '28; M. '36), Structural Engr., San. Dist. of Chicago, 910 South Michigan Ave. (Res., 3955 North Lamon Ave.), Chicago, Ill.

Thomas, Charles Walter (Jun. '35; Assoc. M. '36), Asst. Engr., U. S. Bureau of Reclamation, Denver, Colo.

Tilson, George Henry (Jun. '26; Assoc. M. '36), Asst. Engr., Grade Crossing Dept., N.Y.C.R.R., 466 Lexington Ave., New York (Res., 164 Hylan Boulevard, Rosebank), N.Y.

Trigeiro, William Francis (Jun. '30; Assoc. M. '36), Dist. Designing Engr., SCS, U. S. Dept. of Agriculture, Box 391, Placerville, Calif.

### Reinstatements

Clyde, Harry Schley, Assoc. M., reinstated Dec. 16, 1936.

Darling, Horace Velpeau, Assoc. M., reinstated Dec. 14, 1936.

Fields, Arthur Daniel, Assoc. M., reinstated Dec. 17, 1936.

### Resignations

Bassett, John Benjamin, M., resigned Dec. 21, 1936.

Beatty, Philip Asfordby, M., resigned Dec. 31, 1936.

Birke, Hakan Daniel, Assoc. M., resigned Dec. 31, 1936.

Brown, Frederick Theodore, Assoc. M., resigned Dec. 31, 1936.

Burroughs, Billy Bob, Jun., resigned Jan. 7, 1937.

Chab, Victor, Jun., resigned Dec. 31, 1936.

Chace, Ira Mason, Jr., Assoc. M., resigned Dec. 31, 1936.

Clinton, Robert, Jun., resigned Jan. 7, 1937.

Corns, Harry Cooper, M., resigned Dec. 17, 1936.

DeFrees, Raymond Garfield, Assoc. M., resigned Dec. 31, 1936.

Durbin, Harvey Randolph, M., resigned Dec. 29, 1936.

Eldridge, Maurice Owen, Assoc. M., resigned Jan. 7, 1937.

Ewin, James Perkins, Assoc. M., resigned Dec. 10, 1936.

Farley, William Frederick, Assoc. M., resigned Dec. 31, 1936.

Granoff, David, Assoc. M., resigned Dec. 31, 1936.

Gregory, William Benjamin, M., resigned Dec. 29, 1936.

Gutekunst, George John, Assoc. M., resigned Dec. 31, 1936.

Hartung, Otto Frederick, Assoc. M., resigned Dec. 29, 1936.

Haughwout, Frederick Eugene, Assoc. M., resigned Dec. 31, 1936.

Hubschmitt, Elmer Philip, Assoc. M., resigned Dec. 10, 1936.

Jackson, George Lowell, Jun., resigned Dec. 31, 1936.

James, Willard Whitaker, M., resigned, Dec. 9, 1936.

Jorgensen, Albert, Assoc. M., resigned Dec. 22, 1936.

Kloberg, Edward, M., resigned Dec. 14, 1936.

Leithmann, Warren Justin, Jr., Jun., resigned Dec. 10, 1936.

McClure, Frederick Fenton, Jun., resigned Dec. 31, 1936.

McNamara, Charles John, M., resigned Dec. 23, 1936.

McPike, Martin John, Assoc. M., resigned Dec. 17, 1936.

Newport, Marshall Ross, Jun., resigned Dec. 14, 1936.

Ogden, Horatio Nash, Jun., resigned Dec. 31, 1936.

Paulson, Joseph Bernard, Jr., Jun., resigned Dec. 31, 1936.

Petermann, Hans August, Assoc. M., resigned Dec. 29, 1936.

Raster, Walther, M., resigned Dec. 31, 1936.

Richards, Frederick Tracy, Jun., resigned Dec. 31, 1936.

Rinearson, Horace Wayland, M., resigned Dec. 17, 1936.

Robson, Frederick Thurston, Assoc. M., resigned Dec. 11, 1936.

Ropes, Elihu Harrison, Assoc. M., resigned Dec. 21, 1936.

Anborn, Kingsbury, M., resigned Dec. 31, 1936.

Shaffer, Kenneth Harry, Jun., resigned Dec. 16, 1936.

Shellard, Gordon Duryea, Jun., resigned Dec. 15, 1936.

Siegel, Abram, Jun., resigned Dec. 31, 1936.

Smith, Glenn Shepard, M., resigned Dec. 31, 1936.

Stitzenberger, Wilbert, Jun., resigned Dec. 29, 1936.

Stone, James Allan, Jun., resigned Dec. 31, 1936.

Thayer, Roland Aldrich, M., resigned Dec. 14, 1936.

Thomason, Frank, Jun., resigned Dec. 29, 1936.

Thompson, Edward Percival, Assoc. M., resigned Jan. 7, 1937.

Thomson, William Chase, M., resigned Dec. 29, 1936.

Tiedeman, Frederic William, Jun., resigned Dec. 31, 1936.

Tucker, William Burns, Jun., resigned Dec. 10, 1936.

Ward, Jasper Dudley, M., resigned Jan. 7, 1937.

White, Byron Ellsworth, M., resigned Dec. 31, 1936.

Wurapfic, Joseph, Jun., resigned Dec. 31, 1936.

# Applications for Admission or Transfer

*Condensed Records to Facilitate Comment of Members to Board of Direction*

February 1, 1937 — NUMBER 2

*The Constitution provides that the Board of Direction shall elect or reject all applicants for admission or for transfer. In order to determine justly the eligibility of each candidate, the Board must depend largely upon the membership for information.*

*Every member is urged, therefore, to scan carefully the list of candidates published each month in* CIVIL ENGINEERING *and to furnish the Board with data which may aid in determining the eligibility of any applicant.*

*It is especially urged that a definite recommendation as to the proper grading be given in each case, inasmuch as the grading must be based upon the opinions of those who know the applicant personally as well as upon the nature and extent of his professional experience. Any facts derogatory to the personal character or professional reputation of an applicant should be promptly communicated to the Board.*

*Communications relating to applicants are considered strictly confidential.*

*The Board of Direction will not consider the applications herein contained from residents of North America until the expiration of 30 days, and from non-residents of North America until the expiration of 90 days from the date of this list.*

## MINIMUM REQUIREMENTS FOR ADMISSION

| Grade | General Requirement | Age | Length of Active Practice | Responsible Charge of Work |
|---|---|---|---|---|
| Member | Qualified to design as well as to direct important work | 35 years | 12 years* | 5 years of important work |
| Associate Member | Qualified to direct work | 27 years | 8 years* | 1 year |
| Junior | Qualified for sub-professional work | 20 years † | 4 years* | |
| Affiliate | Qualified by scientific acquirements or practical experience to cooperate with engineers | 35 years | 12 years* | 5 years of important work |
| Fellow | Contributor to the permanent funds of the Society | | | |

* Graduation from an engineering school of recognized reputation is equivalent to 4 years of active practice.

† Membership ceases at age of 33 unless transferred to higher grade.

**The fact that applicants refer to certain members does not necessarily mean that such members endorse.**

## ADMISSIONS

ADAMOWITZ, MICHAEL, New York City. (Age 20.) Refers to L. V. Carpenter, C. T. Schwarze.

BAILEY, EARNEST ALBERT, Ft. Worth, Tex. (Age 57.) Senior Hydr. Engr., Trinity River Canal Assoc. Refers to F. H. Davis, J. W. Gross, J. B. Hawley, E. Hyatt, O. Laurgaard, M. C. Nichols, E. E. Teeter.

BAILEY, SAMUEL MAJOR, Denison, Tex. (Age 43.) Senior Engr., U. S. Engr. Dept. Refers to J. M. Balknap, T. S. Burns, E. D. Gilman, J. D. Justin, T. T. Knappen, W. H. McAlpine, A. Marston, E. M. Moore.

BANNERMAN, GORDON HAROLD, Worcester, Mass. (Age 45.) Asst. Chf. Tramway Engr., American Steel & Wire Co. Refers to J. C. Agnew, A. H. Ayers, F. C. Carstarphen, H. F. Harris, F. T. Hillman, A. G. Roach, R. White.

BENEDICT, GEORGE BERNARD, Moorestown, N.J. (Age 38.) Departmental Engr., Tide Water Associated Oil Co., New York City. Refers to L. E. Camblos, J. K. Finch, J. K. Gannett, B. Lafferty, J. H. Terry.

BERGMAN, VICTOR ROBINSON, New York City. (Age 29.) Estimator and Engr., Godwin Constr. Co.; also Asst. in Civ. Eng., School of Technology, and Instructor in elementary structural design, Coll. of City of New York (evening session). Refers to H. M. Bergman, R. E. Goodwin, R. R. Graham, C. T. Morris, H. J. Plock.

BETHUNE, RODERICK ARNETT, Little Rock, Ark. (Age 34.) Associate Engr., PWA. Refers to H. R. Carter, W. D. Dickinson, A. E. Heagler, K. W. Le Fever, A. M. Lund, D. A. MacCrea.

BRADLEY, EARL HUFF, Burlington, Kans. (Age 37.) Div. Survey Chf., Kansas Highway Comm. Refers to H. D. Barnes, W. V. Buck, L. E. Conrad, W. K. Dinklage, C. I. Felps, M. W. Furr, G. W. Lamb, R. M. Willis, R. B. Wills.

BUCK, CARSON PERRY, Canton, N.Y. (Age 25.) Associate Signalman, U. S. Coast & Geodetic Survey. Refers to W. H. Allison, W. J. Farrisee, F. C. Wilson.

BURLEAUD, RENE, Los Angeles, Calif. (Age 39.) Field Engr., Snow Mfg. Co. Refers to C. S. Clark, C. L. Huff, H. H. Kidder, H. S. Reed, C. Williams, Jr.

CLARK, BRADFORD NORMAN, Scarsdale, N.Y. (Age 29.) Engr. and Estimator for Frank Bracalello, Inc., Gen. Contrs. Refers to B. A. Andrews, F. J. Laverty, D. C. Nolan, Jr., C. T. Schwarze, J. J. Walker.

COOK, JAMES RICHARD, Chappaqua, N.Y. (Age 39.) With Chester M. Everett as Engr.-in-Chg. of project at Danbury, Conn. Refers to C. M. Everett, G. M. Fair, F. H. Hapgood, A. P. Loriot, M. Pirnie, H. G. Porter, F. H. Weed.

COTTER, RALPH EVANS, JR., Oakland, Calif. (Age 23.) Civ. Engr. with Fred H. Tibbetts, San Francisco, Calif. Refers to L. B. Reynolds, F. H. Tibbetts.

CUNNINGHAM, THOMAS PATRICK, Richmond Hill, N.Y. (Age 50.) Asst. Engr. with Pres., Borough of Queens, New York City, acting as Asst. to Engr.-in-Chg., Topographical Bureau. Refers to H. K. Endemann, A. K. Johnson, C. U. Powell, J. C. Riedel, L. M. Schoonmaker, B. Weiss.

DARDEN, WILLIAM ALLEN, JR., Nashville, Tenn. (Age 26.) Surveyman, acting as Office Asst., U. S. Engr. Office. Refers to R. P. Black, C. D. Gibson, H. B. Hooper, M. S. Long, C. E. Perry, F. C. Snow, S. A. Weakley.

DUNLOP, HUGH B GIBSON, Coulee Dam, Wash. (Age 26.) Chainman, U. S. Bureau of Reclamation. Refers to F. M. Berry, H. E. Phelps, M. K. Snyder, J. G. Woodburn, F. A. Wuopio.

DYKTOR, HERBERT GEORGE, St. Louis, Mo. (Age 44.) Industrial Hygiene Engr., Health Div., Dept. of Welfare. Refers to H. E. Frech, W. S. Johnson, C. L. Pool, A. H. Wieters, R. A. Willis.

EBUR, CLIFFORD WHEATON, JR., Arlington, Va. (Age 28.) Draftsman, Dept. of Agriculture, BAE Graphic Sec. Refers to H. L. Bowman, G. D. Houtman, M. C. Knabe, 3d, S. J. Leonard, W. Steinbruch.

ERIM, SUAD KADRI, Pendik, Istanbul, Turkey. (Age 27.) With Eng. Dept., Turkish Army. Refers to H. Cross, J. S. Crandell, W. C. Huntington, S. B. Morris, E. S. Sheiry.

ESTRADA, ALFRED ALBERT, Philadelphia, Pa. (Age 31.) Asst. Engr., Albright & Friel, Inc. Refers to F. S. Friel, J. G. Gruss, J. D. Justin, M. H. Kohler, J. P. H. Liebsch, F. H. O'-Rourke, E. R. Schofield.

FENTON, CLYDE HENRY, Temple, Tex. (Age 39.) Office Engr., Brazos River Conservation and Reclamation Dist. Refers to G. R. Brown, J. C. Carpenter, E. Haquinius, J. A. Norris, J. W. Pritchett.

GRAY, MARVIN AARON, Chicago, Ill. (Age 27.) Refers to T. L. Condron, A. E. Lindau, G. A. Maney, A. Smith, L. T. Wyly.

HARDIMAN, HAROLD JAMES, Glendale, N.Y. (Age 29.) Jun. Accountant, New York & Queens Electric Light & Power Co. Refers to C. T. Schwarze, D. S. Trowbridge.

HOWARD, PAUL FREDERICK, Boston, Mass. (Age 37.) San. Engr. for Whitman & Howard, Engrs. Refers to F. A. Barbour, G. C. Brehm, H. P. Burden, G. M. Fair, F. H. Kingsbury, H. E. Sawtell, A. D. Weston.

HRENNIKOFF, ALEXANDER, Vancouver, B.C., Canada. (Age 40.) Instructor, Dept. of Civ. Eng., Univ. of British Columbia. Refers to W. E. Duckering, A. H. Finlay, J. N. Finlayson, F. Lee, E. G. Matheson, F. P. Shearwood, S. Wilmot.

JOHNSTON, WILLIAM CARLETON, Little Rock, Ark. (Age 38.) Chf. Draftsman, Arkansas Highway Dept. Refers to J. F. Brookes, W. E. Ford, G. L. Fry, J. P. Gallager, L. W. Hall, A. W. Hardy, C. T. Holmes, K. W. LeFever, J. M. Page, W. A. Poe, H. M. Wright.

JOST, LESLIE GORDON, Van Nuys, Calif. (Age 49.) Chf. Engr., Consolidated Steel Corporation, Ltd., Los Angeles, Calif. Refers to O. G. Bowen, H. L. Christie, O. Dunkel, R. W. Gerhart, H. G. Grady, P. E. Jeffers, A. G. Roach, N. Werner.

KOMIAKOFF, LEO NICHOLAS, New York City. (Age 27.) Senior Foreman (Engr.), National Park Service, U. S. Dept. of Interior, Elks Park Camp, Port Jervis, N.Y. Refers to T. Saville, C. T. Schwarze, D. S. Trowbridge.

KRIMGOLD, DOV BER, West Falls Church, Va. (Age 34.) Associate Soil Conservationist, Soil Conservation Service, Washington, D.C. Refers to H. L. Cook, B. A. Etcheverry, S. T. Harding, C. S. Jarvis, H. R. Leach, M. P. O'Brien, C. E. Ramser.

KUTY, EUGENE, Schenectady, N.Y. (Age 26.) Refers to R. A. Hall, A. de H. Hoadley, H. Miller, W. C. Taylor.

LUM, STANLEY CLARK, New York City. (Age 28.) Estimator, A-J Contr. Co., Inc., Gen. Contrs. Refers to C. T. Schwarze, W. T. Sitt.

LUSCZYNSKI, NORBERT JOSEPH, Albany, N.Y. (Age 22.) Jun. Hydr. Engr., U. S. Geological Survey. Refers to A. W. Harrington, J. W. Howe, H. B. Kinnison, C. F. Meyer, E. A. Taylor.

MACMILLAN, WILLIAM WILSON, Riverside, Calif. (Age 29.) Inspector, Metropolitan Water Dist. Refers to H. R. Bolton, C. Derleth, Jr., R. B. Diemer, B. A. Etcheverry, C. G. Hyde, O. J. Schieber, K. Q. Volk.

MURPHY, THORIST FILMORE, Sacramento, Calif. (Age 39.) Associate Engr., Topographical Branch, U. S. Geological Survey. Refers to L. L. Bryan, H. H. Hodgeson, R. R. Monbeck, C. N. Mortenson, J. G. Staack.

NAGTEGAAL, GERRIT PAUL, Milwaukee, Wis. (Age 29.) Eng. Contr., Paul Nagtegaal & Son. Refers to H. L. Davis, H. F. Janda, E. A. Moritz, I. C. Peterson, L. F. Van Hagan.

NEIMAN, ABRAHAM SAMUEL, Springfield, Ill. (Age 39.) Asst. Highway Engr., Illinois Bureau of Bridges. Refers to G. F. Burch, P. Z. Michener, C. E. Morgan, W. A. Oliver, L. E. Philbrook, F. E. Richart, W. N. Schroeder.

NOWELL, JOSEPH CORNELL, JR., Knoxville, Tenn. (Age 35.) Administrative Asst. to Chf. Designing Engr., TVA. Refers to E. A. Dockstader, C. E. Nichols, R. M. Riegel, C. M. Spofford, B. W. Steele, L. J. Towne.

PHELPS, BOYD EDWARD, Laporte, Ind. (Age 35.) Dist. Constr. Engr., State Highway Comm. of Indiana. Refers to J. T. Hallett, C. Hunnell, Jr., W. A. Knapp, G. E. Lommel, J. S. Neibert, A. R. Smith, J. W. Wheeler.

RAHL, MARVIN EDWARD, New York City. (Age 44.) Asst. Engr., Borough of Manhattan. Refers to E. L. Collins, C. I. Colyer, R. P. Davis, H. J. Grathwol, R. J. F. Lucchetti, H. E. Snyder, T. S. Williams.

REICH, STANLEY SCHWARTZ, Brooklyn, N.Y. (Age 38.) Engr., The Arundel Corporation. Refers to J. M. Buckley, E. G. Carey, S. Hargen, F. R. Harris, A. F. Lipari, E. B. Snell, C. C. Sprigg.

SANCHEZ, MANUEL, New York City. (Age 27.) Refers to C. T. Schwarze, D. S. Trowbridge.

SIMATOVICH, ANTHONY PATRICK, San Francisco, Calif. (Age 27.) Jun. Highway Engr., U. S. Bureau of Public Roads. Refers to H. P. Hart, C. C. Morris, R. Pearson, C. H. Sweetser, G. D. Whittle.

SJOSTROM, ROBERT MCDOWELL, Chicago, Ill. (Age 26.) Refers to G. E. Lommel, G. P. Springer, R. B. Wiley.

STEAKLEY, FLOYD, Houston, Tex. (Age 32.) Asst. Res. Engr. Inspector, Texas FBA of PW. Refers to H. E. Elrod, M. C. Nichols, J. A. Norris, W. M. Wilson, N. Wohlfeld.

STRANGE, ORMAN MORTON, Denver, Colo. (Age 35.) Field Engr., Moffat Water Tunnel Project, Denver Board of Water Comm. Refers to H. S. Crocker, D. D. Gross, C. H. Paul, E. H. Schneider, R. J. Tipton.

SULAHIAN, SETRAG, New York City. (Age 46.) Asst. Engr. of Constr., WPA, Queens Highway Dept., being Asst. to Senior Supt. of five projects. Refers to C. E. Conover, E. A. Groves R. L. Pfau, A. I. Raisman, R. Ridgway, G. P. Winn.

TARR, ERNEST ALBERT, Sacramento, Calif. (Age 25.) Chf. of Party with California Statewide Highway Planning Survey. Refers to R. E. Davis, C. Derleth, Jr., F. S. Foote, C. G. Hyde, B. Jameyson, C. T. Wiskocil.

THOM, GEORGE MCLENNAN, Newburgh, N.Y. (Age 28.) Jun. Engr., Orange County Highway Dept. Refers to H. E. Breed, F. X. Conrad, C. A. Gridley, A. W. Green, Jr., C. H. Wing.

TORRE, MARIO DE LA, Cali Colombia. (Age 27.) Constr. and Field Engr., Cia. Colombiana de Electricidad. Refers to A. N. Johnson, S. Ospina, R. H. Skilton, S. S. Steinberg. (Applies in accordance with Sec. 1, Art. I of the By-Laws.)

UNDERHILL, HENRY WILLITS, Jericho, N.Y. (Age 23.) Refers to G. E. Beggs, F. H. Constant, P. Kissam.

VAUGHAN, NORMAN ERNEST, Melbourne, Australia. (Age 34.) Engr.-Mgr., Vacuum Oil Co. Pty., Ltd. Refers to R. R. B. Bennett, J. W. B. Blackman, J. T. Carmichael, P. Caro, L. B. Mercer, C. W. N. Sexton, H. M. Sherrard.

WINKLER, ALBERT LAWSON, Philadelphia, Pa. (Age 27.) Chainman, Pennsylvania R. R. Chf. Engr.'s Office, Pittsburgh, Pa. Refers to D. L. Sommerville, E. D. Walker, E. R. Winkler, Jr.

## FOR TRANSFER

### FROM THE GRADE OF ASSOCIATE MEMBER

BUSSARD, MARCEL JULIAN, Assoc. M., Los Angeles, Calif. (Elected Jan. 26, 1931.) (Age 36.) With WPA as Constr. Inspector on school buildings for City of Los Angeles, Calif. Refers to L. Arosemena, G. M. Dillingham, T. A. Forbes, T. Guardia, F. A. Johnson, H. M. Jones.

CHELLIS, ROBERT DUNNING, Assoc. M., Boston. Mass. (Elected June 4, 1928.) (Age 39.) Engr., Structural Div., Stone & Webster Eng. Corporation. Refers to H. S. Boardman, R. W. Burpee, A. B. Cohen, E. A. Dockstader, F. E. Hertel, C. E. Nichols, E. H. Sprague, G. R. Strandberg, L. J. Towne.

ECKHARD, GEORGE FREDERICK, Assoc. M., Burlington, Vt. (Elected Oct. 11, 1920.) (Age 58.) Dean, Coll. of Eng., Univ. of Vermont. Refers to R. A. Caughey, T. W. Dix, H. L. Tilton, E. L. Waterman, R. C. Wheeler, W. J. Wilgus.

HOLLEY, HARRY HALL, Assoc. M., Visalia, Calif. (Elected Oct. 5, 1909.) (Age 57.) Civ. and Hydr. Engr. Refers to A. D. Edmonston, H. L. Haehl, S. T. Harding, C. L. Kaupke, J. B. Lippincott, W. P. Rowe, G. L. Swendsen.

MURNER, HERBERT KENNETH, Assoc. M., Los Angeles, Calif. (Elected July 14, 1930.) (Age 35.) Refers to A. H. Ayers, F. T. Crowe, B. A. Hall, E. L. Sutherland, R. H. Taylor.

NELSON, FREDERICK GRANT, Assoc. M., Toledo, Ohio. (Elected March 11, 1929.) (Age 41.) Sales Engr., The Dorr Co., Inc., New York City. Refers to T. R. Atkinson, F. Bachmann, E. D. Barstow, F. Bass, C. H. Currie, P. F. Hopkins, J. W. Moore.

PERRY, JOHN EDWIN, Assoc. M., Ithaca, N.Y. (Elected Nov. 25, 1919.) (Age 52.) Asst. Prof. of R. R. Eng., Cornell Univ. Refers to F. A. Barnes, C. Crandall, S. C. Hollister, E. W. Schoder, F. J. Seery, P. H. Underwood, C. L. Walker.

PLUMMER, FRED LEROY, Assoc. M., Cleveland Heights, Ohio. (Elected March 5, 1928.) (Age 36.) Associate Prof. of Structural Eng., Case School of Applied Science; also Cons. Engr. to various companies. Refers to A. L. Alin, G. E. Barnes, J. M. Heffelfinger, Jr., R. Hoffmann, G. B. Sowers, W. J. Watson, A. W. Zesiger.

WHANNEL, RAYMOND LEONALD, Assoc. M., Springfield, Ill. (Elected Junior Aug. 30, 1926; Assoc. M. Oct. 14, 1929.) (Age 38.) Asst. Highway Engr., Illinois Div. of Highways. Refers to M. Blanchard, G. F. Burch, R. D. Dryfoose, C. M. Hathaway, C. E. Morgan, W. N. Schroeder, C. S. Timanus.

### FROM THE GRADE OF JUNIOR

DONATO, DANTE FRANK JOSEPH, Jun., New York City. (Elected Aug. 15, 1932.) (Age 29.) Senior Engr. of Constr., Project Planning Sec., Eng. Dept., WPA, Administrative Sec.; also Instructor, Bldg. Constr. and Estimating, Pratt Inst. (evening session). Refers to J. R. Aikenhead, A. W. Buel, R. Evers, H. Fishgrund, W. T. Sitt.

DUNBAR, T. J., JR., Jun., Pearland, Tex. (Elected Oct. 30, 1933.) (Age 27.) County Engr., Brazoria County, Tex. Refers to E. C. H. Bantel, R. P. Boyd, J. A. Focht, C. L. Hasie H. P. Stockton, Jr., T. U. Taylor.

EAGER, WILLIAM LYLE, Jun., Denver, Colo. (Elected Oct. 10, 1927.) (Age 32.) Asst. to Materials Engr., Dist. No. 3, U. S. Bureau of Public Roads. Refers to L. F. Copeland, R. L. Downing, C. L. Eckel, J. A. Elliott, R. A. Klein, C. E. Learned.

GRIME, LEONARD, Jun., Hamilton, Ont., Canada. (Elected July 16, 1928.) (Age 32.) Structural Draftsman, Hamilton (Ont.) Bridge Co. Refers to C. D. Meals, C. H. Mitchell, J. A. Paquette, J. C. K. Stuart, C. R. Young.

HARLESS, CHARLES MALCOLM, Jun., Port Neches, Tex. (Elected Oct. 1, 1928.) (Age 32.) Constr. Engr., The Texas Co. Refers to G. E. Crews, M. Halpern, J. G. McKenzie, L. B. Ryon, Jr., W. B. White.

MACALPINE, DAVID MUIR, Jun., New York City. (Elected Nov. 12, 1928.) (Age 32.) Tutor, Dept. of Civ. Eng., Coll. of City of New York. Refers to G. E. Barnes, L. Mitchell, F. L. Plummer, J. C. Rathbun, S. Ward.

MOORE, WILLIAM BION, Jun., Denver, Colo. (Elected Nov. 12, 1928.) (Age 29.) Asst. Engr., Federal Power Comm. Refers to J. B. Babcock, 3d, C. B. Breed, J. D. Fitch, R. B. McWhorter, P. von Weymarn, F. S. Warner.

PEDIGO, JAMES ALAN, Jun., South Gate, Calif. (Elected May 23, 1932.) (Age 30.) County Surveyor, Storm Drain Div., Road Dept., Los Angeles County. Refers to W. D. Armstrong, O. F. Cooley, W. J. Fox, R. S. Goodridge, F. B. Gridley, G. W. Jones.

PILLSBURY, ARTHUR FRANCIS, Jun., Riverside, Calif. (Elected Oct. 14, 1930.) (Age 32.) Jun. Irrigation Engr., Div. of Irrigation Investigations and Practice, Coll. of Agriculture, Univ. of California, Berkeley, Calif. Refers to R. L. Derby, E. C. Eaton, J. C. L. Fish, A. Givan, R. V. Meikle, L. B. Reynolds, C. A. Taylor.

POWELL, VIRGIL OSCAR, Jun., Knoxville, Tenn. (Elected July 15, 1929.) (Age 32.) Asst. Hydr. Engr., Navigation Sec., Project Planning Div., TVA. Refers to C. T. Barker, J. S. Bowman, T. T. Knappen, H. V. Pittman, F. C. Snow, R. H. Suttie.

ROGERS, GORDON FARRAND, Jun., San Pedro, Calif. (Elected Jan. 13, 1930.) (Age 32.) Engr. and Supt., Merritt-Chapman & Scott Corporation. Refers to A. F. Barnard, J. W. B. Blackman, W. J. Grodske, C. T. Leeds, R. J. Reed.

SMITH, ROBERT JOHN, Jun., Gaylord, Mich. (Elected Oct. 10, 1927.) (Age 32.) Res. Engr. with State of Michigan, Bldg. Dept. Refers to A. J. Decker, W. R. Drury, G. W. Francis, W. C. Hoad, L. Pearse, E. L. Pflanz.

STAMAN, LILBURN PIERCE, Jun., Sioux City, Iowa. (Elected Nov. 12, 1928.) (Age 30.) With City Engr. as Engr.-in-Chg. of flood control project. Refers to R. L. Carter, P. D. Cook, J. S. Dodds, E. W. Dunn, A. H. Fuller, J. L. Holdefer, F. Kerekes, T. Russell.

THOMAS, THEODOR WILLIAM, Jun., St. Paul, Minn. (Elected Nov. 12, 1928.) (Age 32.) On research at Univ. of Minnesota (on leave from State Dept. of Highways). Refers to F. Bass, A. S. Cutler, A. J. Duvall, W. E. King, G. J. Schroepfer.

Tingey, Willis Alma, Jun., Troy, Mo. (Elected April 30, 1934.) (Age 32.) Asst. Topographic Engr., U. S. Geological Survey, Washington, D.C. Refers to G. D. Clyde, H. H. Hodgeson, O. W. Israelsen, C. L. Sadler, G. S. Smith, J. G. Staack.

Westerhoff, Russell Post, Jun., Paterson, N.J. (Elected Oct. 10, 1927.) (Age 32.) Reserve Army Officer with CCC, U. S. Govt. Refers to J. A. Emery, G. I. Rhodes, C. M. Spofford, W. von Phul, C. C. Whittelsey.

Wiley, Tarley Tarson, Jun., Springfield, Ill. (Elected Oct. 26, 1931.) (Age 28.) With Traffic and Safety Sec., Bureau of Maintenance, Illinois Div. of Highways. Refers to H. B. Belford, C. E. DeLeuw, W. E. DeYoung, E. D. Dryfoose, T. C. Shedd, F. T. Sheets, E. C. Wenger.

Wingo, James Francis, Jun., El Paso, Tex. (Elected Oct. 14, 1929.) (Age 32.) Prin. Eng. Draftsman, International Boundary Comm., American Sec. Refers to F. L. Castleman, R. G. Hosea, L. M. Lawson, J. J. Ledbetter, Jr., V. J. Von Schoeler, W. A. Von Schoeler, W. H. W. Yeo.

*The Board of Direction will consider the applications in this list not less than thirty days after the date of issue.*

# Men Available

*These items are from information furnished by the Engineering Societies Employment Service, with offices in Chicago, New York, and San Francisco. The Service is available to all members of the contributing societies. A complete statement of the procedure, the location of offices, and the fee is to be found on page 87 of the 1936 Year Book of the Society. To expedite publication, notices should be sent direct to the Employment Service, 31 West 39th Street, New York, N.Y. Employers should address replies to the key number, care of the New York Office, unless the word Chicago or San Francisco follows the key number, when it should be sent to the office designated.*

## Construction

Construction Engineer-Superintendent; Jun. Am. Soc. C.E.; New Jersey license; 33; 12 years varied experience in domestic and foreign service. Municipal development, highway, sewer and reinforced concrete foundation and building construction. Field engineer on geological exploration and hydrographic surveys for dock locations (major oil company) in South America. Speaks Spanish and German. Location immaterial. D-5643.

Bridge Designer, Construction; Jun. Am. Soc. C.E.; 32; married; B.S. in C.E., University of Illinois, 1927; graduate study in structural engineering, Iowa State College; member of Tau Beta Pi; Iowa license; 6 months experience in railroad surveying; 9 months as inspector on paving; 7 years in bridge design and shop inspection. Available on 2 weeks notice. Any location; prefers West Coast or Mountain States. D-244-3612-A-2 San Francisco.

## Design

Structural or Bridge Designer; Assoc. M. Am. Soc. C.E.; 53; Michigan license; 3 1/2 years as chief designer; 27 years experience on mill, office, and manufacturing buildings, warehouses, power plants, theaters, museums, postoffices, wharf substructures, apartment buildings, railroad bridges, subways, tunnels, viaducts, highway bridges, and grade separations. Location Detroit, Cleveland, or foreign. D-5592.

Civil Engineer; Assoc. M. Am. Soc. C.E.; doctor's degree in civil engineering; New York license; 46; married; 18 years experience in design and construction of buildings, bridges, and hydraulic works. Unusual experience in design of all types of reinforced concrete structures; American and European practice. Speaks English, Italian, and French; would consider traveling or residing abroad; wishes permanent connection. C-8453.

## Executive

Civil Engineer; Assoc. M. Am. Soc. C.E.; married; 23 years experience, principally on water supply, filtration, sewerage and sewage disposal, city paving, and street and highway construction, highways. Design and construction; 3 years management of ready-mixed concrete business. Prefers connection with responsible firm of consulting engineers or engineering department of sizeable city. B-8942.

Structural Engineer; Assoc. M. Am. Soc. C.E.; married; graduate; registered; over 20 years experience on bridges, buildings, sewage disposal, water filtration, and rigid frames; 6 years in charge of design; 5 years as superintendent of construction; 3 years teaching at University of Wisconsin. Desires permanent executive position, America or British Isles. D-5619.

Civil Engineer; Assoc. M. Am. Soc. C.E.; 52; married; graduate; licensed, New York State; 12 years as chief engineer and manager of water department; in charge of $8,000,000 expansion and development; 8 years irrigation and flood-control experience. D-5604.

Civil Engineer; M. Am. Soc. C.E.; technical graduate; married; 10 years diversified experience on drainage surveys, railroad construction and design of structures, mass transportation studies, and extensive valuation; 20 years in executive capacity directing engineering department and construction forces for a large railway rehabilitation and maintenance program. Available immediately; anywhere in the United States. A-1864.

Civil Engineer; Assoc. M. Am. Soc. C.E.; 45; married; graduate; New York State license; 23 years diversified experience on water works, sewers, investigations for underground water supplies, and reports. B-3642.

Civil Engineer; Assoc. M. Am. Soc. C.E.; 34; married; Christian; graduate of Cornell University; New York licenses; one year with consulting engineer; 8 years as engineer of sewers for city public works department in responsible charge of sewer design, construction, and other city engineering projects. Employed. Desires connection with future. Location immaterial. Hard worker. Excellent recommendations. Available on short notice. D-5617.

Executive or Engineer's Assistant; Assoc. M. Am. Soc. C.E.; married; 34; S.B., Massachusetts Institute of Technology 1927; 6 years experience in building construction; 3 years with government relief agencies; good knowledge of office procedure, estimating, inspecting, cost analysis, purchasing, and reporting; valuable administrative experience. Desires permanent position with manufacturing or engineering firm. Location in New England, preferably Connecticut. D-5672.

Graduate Civil Engineer; Assoc. M. Am. Soc. C.E.; 40; married; B.S., C.E.; 17 years years experience on surveys, estimates, design and construction, sewage disposal, sewers, water supply, paving, harbor construction, and reinforced concrete. Interested in position in East, preferably in or near Washington or Baltimore. D-5669.

## Junior

Graduate Civil Engineer; Jun. Am. Soc. C.E.; 27; A.B., B.S., Columbia University. Desires position with consultant or contractor. Experience consists of building construction and estimating, surveying, valuation, costs and progress reports, and as contractor's engineer and assistant superintendent on installation of large water main, concrete road, and bridge job. Designed falsework for rigid-frame reinforced concrete bridge. D-5593.

Civil Engineer; Jun. Am. Soc. C.E.; graduate; age 29; registered in Pennsylvania; 10 years experience, surveying, drafting, construction, consulting engineer. At present with WPA. As resident engineer, desires position as semi-executive or construction engineer with consulting office or contractor near Scranton or Wilkes Barre. D-5620.

Civil Engineer; Jun. Am. Soc. C.E.; 28; single; graduate of West Virginia University, B.S. in C.E. degree with sanitary option. One year experience in design and construction of swimming pool and water-filtration plant. Experience in land and topographic surveying. Past 8 months on making inspection, water measurement, and maps of coal mines. D-4678.

Graduate Civil Engineer; Jun. Am. Soc. C.E.; 26; single; 2 years in computing and surveying; 1 1/2 years sewerage and drainage design and construction; 1 year building alteration and maintenance. Desires connection as an assistant engineer with some small town, village, or city. Alert, ambitious. D-4729.

Civil Engineer; Jun. Am. Soc. C.E.; 24; B.S.E. and C.E.; experienced in concrete design, estimating, and superintendence; instrumentman giving lines and levels; 2 years experience as topographical draftsman and in the layout and planning of large suburban development. Desires position in any branch of civil engineering. Location immaterial. Available in one week, if necessary. D-5314.

Civil Engineer; Jun. Am. Soc. C.E.; 21; single; B.S., C.E., College of the City of New York, 1936; 6 months experience as field assistant to construction superintendent (large building construction firm) writing construction reports, records of labor and material, timekeeping, drafting, estimating, and surveying; 1 month as structural steel estimator. Desires position with firm of structural engineers or building contractor. Immediately available. D-5645.

Field Engineer; Jun. Am. Soc. C.E.; 30; married; B.Sc.C.E. degree; 7 years field work; surveys and layout work on dams, power houses, and railroads. South American experience; knowledge of Spanish. Desires work with contractor or engineering firm. Will go anywhere. D-1868.

Civil Engineer; Jun. Am. Soc. C.E.; 31; married; B.S. in C.E., Georgia Institute of Technology, 1929; 3 years experience in railroad maintenance; 2 years as computer for U. S. Coast and Geodetic Survey; 6 months highway construction; 6 months piping and electrical layouts. Speaks Spanish fluently. C-6128.

## Teaching

Civil Engineer; M. Am. Soc. C.E.; C.E.; married; 15 years professional experience, principally in the design and construction of buildings, and 5 years teaching experience; excellent instructor with ability to gain confidence of students and put subject across. Available for a professorial appointment on a civil engineering faculty for 1937 session. B-9058.

INSTRUCTOR, CIVIL AND HIGHWAY ENGINEERING; Jun. Am. Soc. C.E.; 31; single; C.E. degree, Pennsylvania State College; majored in highway engineering; minored in city planning, city manager; 5 years in highway engineering, surveys, design, construction, and research; 2 years as instructor (engineering mathematics); experienced tutor; public speaker; engineering publicity; publication work; university faculty position desired with opportunity for research study. Available. D-2776.

## RECENT BOOKS

*New books of interest to Civil Engineers donated by the publishers to the Engineering Societies Library, or to the Society's Reading Room, will be found listed here. A comprehensive statement regarding the service which the Library makes available to members is to be found on page 77 of the Year Book for 1936. The notes regarding the books are taken from the books themselves, and this Society is not responsible for them.*

BEIHEFTE ZUM GESUNDHEITS-INGENIEUR, Reihe II, Heft 17. EXPERIMENTALBEITRAG ZUR RAUMAKUSTIK, by H. Stumpp. Munich and Berlin, R. Oldenbourg, 1936. 20 pp., illus., diagrs., charts, tables, 12 × 9 in., paper, 4.40 rm.

This paper is concerned with the acoustic properties of indoor and open-air auditoriums and with the use of acoustic measurements in improving them. Methods of measuring the various acoustic properties are described, their application to special actual cases is illustrated, and some general principles for obtaining satisfactory hearing are laid down.

BEITRAG ZUR BERECHNUNG VON MASTFUNDAMENTEN, 3 ed. By H. Fröhlich. Berlin, Wilhelm Ernst & Sohn, 1936. 81 pp., illus., diagrs., charts, tables, 10 × 7 in., paper, 7.50 rm. (5.65 rm. in United States.)

This work provides a comprehensive study of the design of foundations for the masts and towers of transmission lines. The formulas are developed fully for usual and special conditions, and their use is shown by worked examples. The new edition has been thoroughly revised.

BÉTON ARMÉ (Agenda Dunod) by V. Forestier, 10 ed., 336 pp.; CONSTRUCTION MÉCANIQUE (Agenda Dunod) by J. Izart, 56 ed., 340 pp.; ÉLECTRICITÉ (Agenda Dunod) by L.-D. Fourcault, 56 ed., 392 pp.; MÉTALLURGIE (Agenda Dunod) by R. Cazaud, 53 ed., 326 pp.; MINES (Agenda Dunod) by E. Stalinsky, 56 ed., 300 pp.; and PHYSIQUE INDUSTRIELLE (Agenda Dunod) by J. Izart, 17 ed., 374 pp. Paris, Dunod, 1937. Diagrs., charts, tables, 6 × 4 in., cloth, 20 frs. each.

These pocketbooks contain numerical and other data frequently wanted by engineers engaged in machine construction, reinforced concrete, electrical engineering, mining, metallurgy, and power plant work. They are small enough for the pocket, are revised annually, and are sold at a very low price.

CONVENTION PROCEEDINGS, 1935–1936, AMERICAN ROAD BUILDERS' ASSOCIATION. Edited by Charles M. Upham. Washington, D.C., American Road Builders' Association, 1936. 992 pp., illus., tables, diagrs., charts, 9 × 6 in., leather, $10 (free to members).

This volume, which presents in two parts the 1935 and 1936 convention proceedings of the American Road Builders' Association, represents a national cross-section of the latest theory and practice on all subjects of major interest to road builders. There are also reports by thoroughly qualified authorities on planning, financing, administration, legislation, safety, and other important factors in highway construction.

FORSCHUNGSHEFT 381. STRÖMUNGSFORM UND DURCHFLUSSZAHL DER MESSDROSSELN. By F. Kretzschmer. Berlin, VDI-Verlag, Nov.-Dec., 1936. Illus., diagrs., charts, tables, 12 × 6 in., paper, 5 rm.

This report presents the results of a study of flow through orifices, undertaken to throw light upon the laws that govern it. The basis for the theory of orifice friction and the coefficients of flow and resistance are discussed.

HANDWÖRTERBUCH DER GESAMTEN TECHNIK UND IHRER HILFSWISSENSCHAFTEN. 2 vols. By R. Koch and O. Kienzle. Stuttgart and Berlin, Deutsche Verlags-Anstalt, 1935. Vol. 1, 718 pp.; Vol. 2, 788 pp., illus., diagrs., charts, tables, 11 × 7 in., half-leather, 72 rm.

An excellent dictionary of engineering and technology is provided in this two-volume work, which covers the same ground as Lueger's *Lexikon der gesamten Technik*, but in much more concise fashion and with the inclusion of later information. The definitions are clear and extensive enough for ordinary needs. The work can be recommended to all who need a dictionary of German technical terms.

THE IMPROVEMENT OF THE LOWER MISSISSIPPI RIVER FOR FLOOD CONTROL AND NAVIGATION, 3 vols. Prepared by Maj. D. O. Elliott under the direction of Brig. Gen. T. H. Jackson. Vicksburg, Miss., U. S. Waterways Experiment Station, 1932. 345 pp., illus., tables, maps (71 plates), 9 × 6 in., paper, $6 per set (volumes not sold separately).

These volumes summarize approximately one hundred years of cumulative study and experience on the Mississippi. A history of the river is also given. References are made in the text to the detailed data contained in reports and studies, which have been made from time to time in the past, and a condensed bibliography is included.

INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING, Zurich, Switzerland. MEMOIRES, ABHANDLUNGEN, PUBLICATIONS, Vol. 4. Zurich, Gebrüder Leeman & Co., 1936. Illus., diagrs., charts, tables, 10 × 7 in., paper, 30 Swiss frs.

This volume, containing twenty-nine papers on matters of theoretical or practical interest to structural engineers, is published in connection with the second congress of the International Association for Bridge and Structural Engineering, held in Berlin in 1936. A wide variety of questions is represented, including a new method for designing steel structures, failures of electrically welded bridges, the theory of the suspension bridge, the effects of smoke on structures, and reinforced concrete foundations. The papers are in French, German, or English, with English summaries.

INTRODUCTION TO THEORETICAL SEISMOLOGY. Part 1, Geodynamics. By. J. B. Macelwane and F. W. Sohon. New York, John Wiley & Sons, 1936. 366 pp., illus., diagrs., charts, maps, tables, 9 × 6 in., cloth, $6.

This volume forms the first part of a treatise on theoretical seismology, of which the second part—on seismometry—appeared four years ago. The part now published treats comprehensively of the mathematical and physical theory of seismology. The mechanics of earthquake movements, the distribution of the elastic stresses and strains in the rocks, and the paths of the resulting elastic waves are analyzed. Each chapter has a brief bibliography.

DIE KNICKFESTIGKEIT VON STABEN UND STÄBWERKEN. By J. Ratzersdorfer. Vienna, Julius Springer, 1936. 321 pp., diagrs., charts, tables, 9 × 6 in., cloth, 28.80 rm.; paper, 27 rm.

An investigation of a number of important problems of elastic stability. Some twenty-nine cases of bars and frameworks are considered, and their resistance to buckling under various conditions is studied and detailed solutions are provided. The problems are important ones in the statics of structures, and the methods can be easily applied to other cases.

LABORATORY MANUAL FOR CHEMICAL AND BACTERIAL ANALYSIS OF WATER AND SEWAGE, 2 ed. By F. R. Theroux, E. F. Eldridge, and W. L. Mallmann. New York and London, McGraw-Hill Book Co., 1936. 228 pp., diagrs., tables, 8 × 6 in., cloth, $2.50.

This manual gives concise, specific directions, in outline form, for making the determinations necessary for the control of water and sewage treatment plants, for analyzing polluted waters, and for examining industrial wastes.

THE MECHANICS OF TURBULENT FLOW. By Boris A. Bakhmeteff. Princeton, the Princeton University Press, 1936. 101 pp., figs., diagrs., charts, 9 × 6 in., cloth, $3.50.

A series of lectures delivered under the William Pierson Field Foundation at Princeton University in February 1935. Professor Bakhmeteff presents here the recent findings of the Prandtl and Karman schools in a systematic and simple form. Only the most elementary mathematical means are used, the aim always being to emphasize the physical substance of the phenomena.

A SURVEY OF THE PRESENT ORGANIZATION OF STANDARDIZATION, NATIONAL AND INTERNATIONAL, published by the Central Office of the World Power Conference, London, W.C. 2 (36 Kingsway), 1936. 55 pp., tables, 11 × 7 in., paper, 3s. 6d. (Gift of American National Committee, Interior Bldg., Washington D.C.)

This brochure presents the facts regarding the national organization of standardization in thirty-three countries, and also of two international bodies. The organizations in each country are described and their functions explained. The report was prepared by the International Executive Council of the World Power Conference.

SYMPOSIUM ON HIGH-STRENGTH CONSTRUCTIONAL METALS. Pittsburgh Regional Meeting, A.S.T.M., March 4, 1936. Philadelphia, American Society for Testing Materials, 1936. 126 pp., illus., diagrs., charts, tables, 9 × 6 in., paper, $1.25; cloth, $1.50.

This brochure contains five papers presented at a recent meeting of the Society. The papers discuss alloys of aluminum, magnesium, and copper and of nickel, carbon and low-alloy steels, and corrosion-resisting steels. The chemical and physical properties of these materials, and their manufacturing and fabricating properties are presented.

THEORY OF MODERN STEEL STRUCTURES. Vol. 1, Statically Determinate Structures. By L. E. Grinter. New York, Macmillan Co., 1936. 317 pp., illus., diagrs., charts, tables, 9 × 6 in., cloth, $4.

This volume contains an undergraduate course in the analysis of statically determinate structures. An introductory chapter on the history of structural engineering and the great buildings of the world is followed by chapters on the theory of stress analysis, and on the analysis of stresses in steel mill buildings, highway and railway truss bridges, the plate girder, and tall steel buildings. The presentation is a simple one, without long mathematical formulas, and unusual structures are not discussed.

WATERWAY ENGINEERING. By Otto Franzius; translated by Lorenz G. Straub. Cambridge, the Technology Press (Massachusetts Institute of Technology), 1936. 527 pp., illus., tables, diagrams., charts, 9 × 6 in., cloth, $7.

The third of a series of translations of German books on hydraulics initiated by the late John R. Freeman, this volume deals with the design, construction, and maintenance of navigable waterways. The translator's intent has been not to transplant German methods of river regulation in America, but rather to disseminate some of the knowledge of over a century's accumulation in a country where the improvement of waterways has been a paramount issue.

WIND-PRESSURE ON BUILDINGS. Experimental Researches (second series). (Ingeniørvidenskabelige Skrifter A Nr. 42.) By J. O. V. Irminger and Chr. Nøkkentved; translated from the Danish by A. C. Jarvis and O. Brødsgaard. Copenhagen, Danmarks Naturvidenskabelige Samfund, 1936. 85 pp., diagrs., charts, tables, 10 × 7 in., paper, 10 kr.

This report is a collective account and discussion of experiments conducted during the years 1930–1936 in the Structural Research Laboratory of the Royal Technical College, Copenhagen. The streamflow conditions for bodies placed on the ground, variations of wind pressure on sharp-edged bodies, the effect of screens, and the wind pressure on sheds and partly open buildings were investigated.